Appendix H

SCAQMD Source Test Report
Foss Plating, Santa Fe Springs, California

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South Coast
Air Quality Management District
21865 E. Copley Drive, Diamond Bar, CA 91765-4182
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SOURCE TEST REPORT

98-112

Conducted at

Foss Plating Company
8140 Secura Way
Santa Fe Springs, CA 90670

NICKEL EMISSIONS FROM A SEMI-BRIGHT NICKEL ELECTROPLATING TANK WITH AND WITHOUT AIR AGITATION

TESTED:	October 24 -25, 1998
ISSUED:	December 30, 1998
REPORTED BY:	Michael Garibay Air Quality Engineer II

REVIEWED BY:

Edward J. Ramirez
Senior Air Quality Engineer

MONITORING AND ENGINEERING BRANCH

MONITORING AND ANALYSIS DIVISION

BACKGROUND

a. Firm. ....Foss Plating Company

b. Test Location ....8140 Secura Way, Santa Fe Springs, CA 90670

c. Unit Tested..Semi-Bright Nickel Electroplating Tank

d. Test Requested by..............................Jill Whynot, Stationary Source Compliance, (SSC) (909)396-3104

e. Reason for Test Request......................Develop Emission Factors for Rule 1401

f. Dates of Test..October 24, & 25,1998

g. Source Test Performed by ....E. Ramirez M. Garibay, G. Kasai, C. Willoughby

h. Test Arrangements Made Through ......Carol Foss-McCracken (562) 945-3451 Paul Huffman (562) 945-3451

i. Source Test Observed by......................Victor Foss, (562) 945-3451 Hugh Brown, Pacific Environmental Services, Inc. (PES) (626) 856-1400

RESULTS

Nickel Emissions from a Semi-Bright Nickel Electroplating Tank - with Air Agitation

Run #	$lb/(hr\text{-}scfm_{air})$	$lb/(hr\text{-}ft^2_{tank})$	$lb/(hr\text{-}ft^2_{parts})$	mg/dscm	mg/(A-hr)
1	2.04×10^{-5}	1.06×10^{-5}	9.43×10^{-6}	0.622	0.214
2	2.46×10^{-5}	1.28×10^{-5}	1.14×10^{-5}	0.721	No Plating
Average	2.25×10^{-5}	1.17×10^{-5}	1.04×10^{-5}	0.672	0.214
Workplace Background	-	-	-	0.050	-

Nickel Emissions from a Semi-Bright Nickel Electroplating Tank - No Air Agitation

Run #	lb/hr	$lb/(hr\text{-}ft^2_{tank})$	$lb/(hr\text{-}ft^2_{parts})$	mg/dscm	mg/(A-hr)
1	1.62×10^{-3}	1.69×10^{-5}	1.50×10^{-5}	0.99	0.340
2	1.90×10^{-3}	1.98×10^{-5}	1.76×10^{-5}	1.13	0.399
Average	1.76×10^{-3}	1.83×10^{-5}	1.63×10^{-5}	1.06	0.369
Workplace Background	-	-	-	5.33×10^{-3}	-

Note: See PROCESS DESCRIPTION and CONCLUSION sections for issues relating to operating conditions during testing.

INTRODUCTION

The South Coast Air Quality Management District (SCAQMD), is attempting to gather information on emissions from plating and metal treating processing from nickel plating facilities. The testing was requested to provide improved data on emissions from these operations and address unresolved issues under SCAQMD Rule 1401. The results of the testing are intended to be used as emissions factors in health risk exposure assessments.

Previous testing conducted by the Metal Finishing Association of Southern California (MFASC) and the California Air Resources Board (CARB) consisted of triplicate tests for nickel from nickel electroplating. Issues were raised during the review of the MFASC test regarding high levels of background nickel and potential fugitive losses. The scope of the testing was later expanded during an SCAQMD effort to measure nickel emissions from electroless nickel plating operations, hydrogen chloride from metal acid treating tanks and sodium hydroxide from metal treating tanks at nickel plating facilities. The complete SCAQMD testing series in the project consists of SCAQMD Source Tests: 98-105, 98-106, 98-107, 98-108, 98-109, 98-110, 98-111, and 98-112.

The test plan for the SCAQMD testing was developed via a cooperative effort with the MFASC. This test report incorporates and addresses comments from representatives from both the SCAQMD and MFASC during weekly meetings from the project's beginning to end. The testing was conducted at a volunteer MFASC member facility. The sampling was conducted by SCAQMD Methods and Testing staff. The analysis was conducted by the SCAQMD laboratory and SCAQMD contractor.

This source test was designed to address issues raised during both the MFASC and SCAQMD previous testing efforts. The facility and tank were selected for testing by the MFASC. Since the past MFASC testing was also conducted at this facility, it was thought that a comparison could be made to the existing data. The tank was also selected due to MFASC concerns from the past SCAQMD test that the relatively small (3' x 5') host tank may not be representative of larger tank emissions. Validity concerns regarding testing approach raised during the past testing are addressed in the approach employed in the current test effort.

The current test consists of two sets of duplicate two hour sampling runs with one set run operating without air agitation and the second set run with the air agitation. The results are reported in various units.

PROCESS DESCRIPTION

Background

In the plating industry, nickel plating is employed as a decorative and/or protective layer over a variety of metal pieces. The nickel plating can be used as a final finish or covered with a thin plating of chromium as with decorative chrome applications. The nickel plating can be conducted using electrodes and electromotive force or using an electroless process. Emissions are produced as small droplets of the solution in aerosol form due to bubbling in the tanks caused by electrolysis or other processes such as air agitation commonly employed to enhance the plating process.

In the electrolytic plating process, the parts are immersed in an acidic solution with ionic nickel where a current is applied so that solid nickel is plated onto the parts. An immersion heater can be employed in the plating tanks to maintain a desired plating bath temperature. This type of plating employs a surface tension reducing agent to reduce the surface tension to approximately 35 dynes/cm for purposes of minimizing pitting in the plating process. The solutions within the tanks are agitated by pump recirculation and/or by bubbling with air. Either a bright or semi-bright plated finish can be accomplished depending on the additives in the plating solution. The tanks are equipped with rectifiers to produce a low voltage high amperage DC current. According to the Lawrence J. Durney, *Electroplating Engineering Handbook*, the metal parts are plated with a current density of 20 - 50 amperes per square foot of plating surface area. The majority of the existing nickel electroplating tanks are not vented by a dedicated ventilation system. The buildings that house these processes, typically employ some type of ventilation system which may be forced draft, natural draft, or cross draft in nature.

For the electroless nickel plating, the plating is driven by difference in electropotential. The solution differs from the electroplating solution to enhance this process. For electroless applications, since the solutions contain odiferous compounds such as ammonia, the plating tanks typically include ventilation systems at a close proximity above the plating tanks to draw emissions from the plating tanks out of the work space.

The nickel platers also employ both hydrochloric acid and sodium hydroxide metal treating processes. The hydrochloric acid process is an etching process in which bubbling occurs due to gasses produced as the metal is etched. The sodium hydroxide process can be employed in by spraying, electrocleaning, etching (for aluminum), or soak cleaning with a detergent. Of the sodium hydroxide processes, the soak cleaning is expected to produce the least amount of emissions, while the spraying is expected to produce the highest.

Nickel Plating Operation During Testing

During testing, the nickel electroplating tank was operated during active plating for the entire test period. Unlike either of the past testing efforts, the parts were not removed to simulate drag-out effects. This was done both because of the difficulty of removing parts with the test hood in place and the belief that the drag-out process does not significantly affect emissions. Steel dummy parts were used as a plating substrate as shown in Figure 1. The number of dummy parts was selected by the facility as representative of normal operation of the host tank. The parts were then measured for surface area and a plating amperage was selected for a plating current density of exactly 20 amperes per square foot. This current density was chosen as to be as consistent as possible with the past MFASC testing current density of 17 amperes per square foot while also remaining within the range of normal nickel plating as specified in the *Electroplating Engineering Handbook*. The chosen current density was also verified by discussion with the MFASC to be appropriate for representing typical nickel plating. The parts were submerged entirely in the plating solution.

The actual applied current density was calculated using the surface area of the dummy parts. The tank was equipped with a circulation pump and filter system. During normal operation, the circulation pump discharges the solution above the level in the tank which was observed to produce a certain amount of splashing. During the non-air agitated tests, the discharge was extended to below the level of the tank so that the splashing in the tank would not affect the measurement of emissions from the plating. To achieve normal operation under the air agitated condition, the discharge was maintained above the level in the tank. Photographs of the host plating tank and the surface of the solution both with and without air agitation are shown in Figures 2 through 7. The following are the specifications of the nickel plating tank and the lists of operating conditions that were monitored during the each of the test runs:

Tank Dimensions	Type of Plating
96"W x 120"L x 63"H	Semi-Bright Nickel

Operating Conditions Recorded During Testing - Air Agitation Run #1

Freeboard Height	4.0	inches
Plating Solution Temperature	139-142	°F
Plating Solution Nickel Content	5.85	oz/gal
Plating Solution Nickel Sulfate Content	18.7	oz/gal
Plating Solution Nickel Chloride Content	6.72	oz/gal
Plating Solution Boric Acid Content	4.03	oz/gal
Plating Solution pH	4.75	pH
Plating Solution Surface Tension	47.0	dynes/cm
Ampere-hour Usage	4827	A-hr
Elapsed Time Between A-hr Readings	2.23	hr
Plating Voltage	9.6	volts
Average Amperage Applied	2162	A-hr/hr
Calculated Current Density	20.0	A/ft^2
Number of Dummy Parts	23	channels
Total Surface Area of Plated Parts	108.2	ft^2
Plating Period within Test Run	120	min / test run
Duration of Test Runs	120	min /test run
Capture Efficiency of Ventilation System	100	%
Ventilation Rate	522	acfm
Air Agitation Rate	49.9	scfm
Air Agitation Rate per Unit Solution Surface Area	0.52	$scfm/ft^2$
Part Agitation Rate	0	in/min
Solution Circulation Rate	40-50	gpm (estimated)
Solution Discharge Location	5"	above surface

Operating Conditions Recorded During Testing - Air Agitation Run #2

Freeboard Height	4.1	inches
Plating Solution Temperature	132-139	°F
Plating Solution Nickel Content	5.85	oz/gal
Plating Solution Nickel Sulfate Content	18.7	oz/gal
Plating Solution Nickel Chloride Content	6.72	oz/gal
Plating Solution Boric Acid Content	4.03	oz/gal
Plating Solution pH	4.75	pH
Plating Solution Surface Tension	47.0	dynes/cm
Ampere-hour Usage	0	A-hr
Elapsed Time Between A-hr Readings	0	hr
Plating Voltage	0	volts
Average Amperage Applied	0	A-hr/hr
Calculated Current Density	0	A/ft^2
Number of Dummy Parts	0	channels
Total Surface Area of Plated Parts	0	ft^2
Plating Period within Test Run	0	min / test run
Duration of Test Runs	0	min /test run
Capture Efficiency of Ventilation System	100	%
Ventilation Rate	535	acfm
Air Agitation Rate	49.9	scfm
Air Agitation Rate per Unit Solution Surface Area	0.52	$scfm/ft^2$
Part Agitation Rate	0	in/min
Solution Circulation Rate	40-50	gpm (estimated)
Solution Discharge Location	5"	above surface

Operating Conditions Recorded During Testing - No Air Agitation Run #1

Freeboard Height	4.1	inches
Plating Solution Temperature	132-135	°F
Plating Solution Nickel Content	5.85	oz/gal
Plating Solution Nickel Sulfate Content	18.7	oz/gal
Plating Solution Nickel Chloride Content	6.72	oz/gal
Plating Solution Boric Acid Content	4.03	oz/gal
Plating Solution pH	4.75	pH
Plating Solution Surface Tension	47.0	dynes/cm
Ampere-hour Usage	4792	A-hr
Elapsed Time Between A-hr Readings	2.68	hr
Plating Voltage	9.5	volts
Average Amperage Applied	2159	A-hr/hr
Calculated Current Density	20.0	A/ft^2
Number of Dummy Parts	23	channels
Total Surface Area of Plated Parts	108.2	ft^2
Plating Period within Test Run	120	min / test run
Duration of Test Run	120	min /test run
Capture Efficiency of Ventilation System	100	%
Ventilation Rate	489	acfm
Air Agitation Rate	0	scfm
Air Agitation Rate per Unit Solution Surface Area	0	$scfm/ft^2$
Part Agitation Rate	0	in/min
Solution Circulation Rate	40-50	gpm (estimated)
Solution Discharge Location	5"	below surface

Operating Conditions Recorded During Testing - No Air Agitation Run #2

Freeboard Height	4.2	inches
Plating Solution Temperature	136-140	°F
Plating Solution Nickel Content	5.85	oz/gal
Plating Solution Nickel Sulfate Content	18.7	oz/gal
Plating Solution Nickel Chloride Content	6.72	oz/gal
Plating Solution Boric Acid Content	4.03	oz/gal
Plating Solution pH	4.75	pH
Plating Solution Surface Tension	47.0	dynes/cm
Ampere-hour Usage	4181	A-hr
Elapsed Time Between A-hr Readings	1.93	hr
Plating Voltage	9.6	volts
Average Amperage Applied	2162	A-hr/hr
Calculated Current Density	20.0	A/ft^2
Number of Dummy Parts	23	channels
Total Surface Area of Plated Parts	108.2	ft^2
Plating Period within Test Run	120	min / test run
Duration of Test Run	120	min /test run
Capture Efficiency of Ventilation System	100	%
Ventilation Rate	517	acfm
Air Agitation Rate	0	scfm
Air Agitation Rate per Unit Solution Surface Area	0	$scfm/ft^2$
Part Agitation Rate	0	in/min
Solution Circulation Rate	40-50	gpm (estimated)
Solution Discharge Location	5”	below surface

TESTING METHODOLOGY

The testing consisted of two sets of duplicate two hour sampling runs with one set run under the air agitation operating condition and the second set run without the air agitation. The applied amperage during plating was obtained from a calibrated amp-hour meter and the elapsed time. The amp-hour meter was calibrated by Atlas Testing Laboratories on May 13, 1998.

A temporary reduced draft ventilation system was designed and constructed both to isolate the process and collect the resulting nickel emissions in a manner to both facilitate the emissions measurement and to address concerns by the MFASC. The main MFASC concern was that a high flow ventilation system, such as a dedicated side-draft ventilation system may produce higher emissions due to entrainment of large splashed droplets that potentially fall back into the tanks or to the ground and may not become emissions to the atmosphere.

The temporary reduced draft system was designed to simulate emissions to the atmosphere of an unventilated tank. Mass emissions collected in the duct of a ventilated tank may be higher due to this effect. The temporary ventilation system consisted of 40"L x 40"W x 56"H hood suspended at a distance of 8 inches above the solution surface in the center of the host tank. The hood was vented to a small blower which was set to achieve a specific velocity vertically through the hood. The height of the hood was 1.4 times the equivalent diameter of its base. A straight run of ducting between the hood and the blower was used to isolate and measure the emissions from the tank.

Clear plastic sheets were used to cover the uncovered portion of the host tank. The plastic was also suspended at a height of 8 inches above the solution surface. Two openings of approximately 8 inches wide were left at either of the shorter 8 ft. sides of the tank to allow air to enter the space above the tank The hood and tank cover vent system operated as follows: The air entered at both of short ends of the tank and swept across the space between the tank and cover at a specified velocity. The air then flowed into the hood and traveled upwards through the hood at the specified velocity. Both the hood and the space above the tank acted as a settling zone where larger droplets that would normally not be carried away from the tank are allowed to fall back into the tank. By using a hood that has a smaller cross section than the tank, a lower dilution air rate can be employed. The use of this lower dilution air rate has the advantage of increasing the concentration in the duct which results in a lower relative error in the emission measurement. The approach also has the advantage of making the effects of contamination such as that in the ambient air to be much less significant as compared to that experienced in the past MFASC test. A schematic of this emissions capture system is shown in Figure 8. A photograph of the hood connected to the host tank is shown in Figure 9.

The appropriateness of the hood height was determined by a small scale 16"W x 20"L x 25"H hood connected to a small blower to simulate the full scale design. At a ventilation rate of 50 ft/min as determined by a calibrated vane anemometer, the height of the hood was sufficient to create a uniform velocity over the lower cross-section of the hood and maintain this uniformity for the lower one third of the hood. This was done to ensure that no high or low velocity zones were present as to defeat the purpose of the hood in its lower section.

As discussed in meetings with SCAQMD Methods and Testing staff and MFASC, the specific velocity was chosen to be approximately 50 ft/min. This specific velocity was chosen for the following reasons:

1. The velocity is considered as the minimum velocity at which 100% capture of actual emissions to the atmosphere can be achieved. This was verified using the small scale capture hood and a smoke test.

2. The velocity is sufficiently low as to not overestimate the range of velocities that may be encountered in a building that houses the process. This is important since these internal air currents are responsible for transporting the emissions to the atmosphere. For purposes of comparison, 50 ft/min equates to 0.57 miles per hour. Assuming that outdoor wind speeds typically vary from 3 -10 mph, it is not unreasonable to assume that 0.57 mph indoor air movements can be induced either by open doors, or the building's ventilation system.

3. According to the *American Conference of Governmental Industrial Hygienist Industrial Ventilation Manual,* 50 fpm is the indoor air speed created by an effective air conditioning system.

4. Calculations of settling velocity of small aerosols shows that small aerosol droplets less than 10 microns in diameter are capable of remaining airborne for several minutes, and much longer in moving air.

5. Past testing for cadmium emission factor has been successfully employed using a similar capture velocity.

Two large doors on the west side of the building provided a limited supply of outside air to the building. This air flow path in the building was studied by smoke test. The air in the building was observed to enter through the doors and exit through the roof vents above the tank area. The space immediately above the tank area, however, was observed to be stagnant. The exhaust from the hood was directed into the path of the air flowing through the building so that the nickel was swept from the building to avoid the affects of hood exhaust recirculation.

The sampling was conducted on a weekend so that background nickel in the building was allowed to either ventilate or settle out of the building air overnight. The non-air agitation tests were conducted before the air agitation tests to minimize the amount of background nickel present both in the air and in the collection equipment during the non-air agitated test.

SAMPLING AND ANALYTICAL PROCEDURES

Flow Rate

The gas velocity within the sampling duct was measured during each sampling run at eight points within the duct cross section as according to SCAQMD Methods 1.2 and 2.3. This was performed simultaneously with the pollutant sampling using a NIST traceable standard type Pitot tube with a differential pressure manometer, and a type "K" thermocouple with a potentiometer (Figure 10). The apparatus was checked for leaks both before and after use by introducing a pressure head and blocking the flow at the Pitot tip. An observation of the resulting stabilization in pressure at the manometer verified the absence of leaks in the system. The stack's access ports were located using the approach of SCAQMD Method 2.3 for ducts of less than 12 inches in diameter. Using this approach, the sampling access ports were located approximately eight stack diameters downstream and greater than two stack diameters upstream from flow disturbances. The velocity access ports were located approximately five stack diameters downstream from the sampling access ports and greater than two stack diameters upstream from a flow disturbance. This configuration meets the minimum and most of the preferred SCAQMD Method 1.2 requirements for measurement site location.

A cyclonic flow check was also performed to check for the presence of flow that is non-parallel to the duct wall which can cause a bias in the flow measurement. This was accomplished by rotating an S-type Pitot tube at each traverse point until a zero pressure differential results at the gauge. The null angle is determined with an inclinometer as the deviation of the Pitot angle with respect to a plane perpendicular to the theoretically straight duct flow. Data from the cyclonic flow check shows that the duct does not exhibit cyclonic flow as defined in Method 1.1.

The volumetric flow rate was calculated for each sampling run using the stack's cross sectional area and average gas velocity. The flow rate was corrected to standard conditions by using the stack temperature and pressure along with the barometric pressure measured with a calibrated aneroid barometer. The flow rate was also corrected to dry conditions using the moisture content as determined by the SCAQMD Method 4.1 weight gain from the nickel sampling train as described in the following section.

Nickel Sampling - Modified CARB Method 433

A nickel sample was collected during each sampling run using Modified CARB Method 433. The modification was the same as that employed by MFASC contractor, PES, which consists of the use of a back-up filter as opposed to the up-front heated filter.

The sample was collected from the locations within the sampling duct previously described in the velocity measurements. Each sample was collected over a period of 120 minutes using a sampling train consisting of a glass probe and nozzle connected by a four foot length of non-reactive tubing to the first of two Greenburg-Smith impingers each containing 100 ml of 0.1N nitric acid solution, an empty bubbler, a 0.5 micron glass fiber back-up filter, and a bubbler containing tared silica gel desiccant.

The impinger assembly was connected to a vacuum pump and a calibrated dry gas meter as shown in Figure 11. The sampling apparatus was checked for leaks both before and after sampling by blocking the flow at the probe tip. An observation of the resulting decrease in flow at the meter to less than 0.02 cfm or four percent of the sampling rate indicated an acceptable leak rate. The impinger train was contained within an ice bath to condense water and other condensable matter present in the sample stream.

The impinger train was returned to the SCAQMD laboratory for recovery. The recovered solutions were dissolved in concentrated nitric acid and boiled down according to CARB Method 433 and sent to West Coast Analytical Service, Inc. for analysis. Nickel collected in the nozzle, probe, impingers, and filter was determined using CARB Method 433 by Inductively Coupled Plasma Mass Spectrometry (ICPMS).

At the request of the MFASC, workplace background sampling within the plating facility was conducted. The workplace background samples were collected using the same configuration and analysis as that used for emissions sampling. The samples were collected at a distance of approximately three feet from the plating tank in the upwind direction with respect to airflow in the building at approximately the same height that the air entered the collection hood. The first workplace background sample represents composite sampling of the facility air during the non-air agitation runs. The second workplace background sample represents composite sampling of the facility air during the air agitation runs. A blank field sample train was also analyzed as above for quality control purposes.

Capture Efficiency

The capture efficiency was determined by a smoke test. The smoke test was accomplished using titanium chloride smoke generating tubes. This technique can be used to verify 100% capture or conversely less than 100% capture by observing the flow of the smoke into the capture hood. The observation of complete capture of the smoke indicated 100% capture efficiency. The smoke test was conducted at both of the open ends of the tank between the temporary capture sheets and the tank. Photographs of the actual smoke test are shown in Figure 12.

The height of the capture hood and the ventilation rates were adjusted in an attempt to achieve the 50 ft/min specified velocity vertically within the hood as well as horizontally across the tank. The actual velocities achieved during each sampling run were calculated from the ventilation flow rate and the cross sectional areas. The results of these calculations are presented in the following table:

Run #	Vent Velocity (fps)	Vertical Velocity in Hood (fpm)	Horizontal Velocity Between Hood and Tank (fpm)
Run #1 with Air	32.56	47.5	49.4
Run #2 with Air	33.34	48.6	50.6
Run #1 no Air	30.49	44.5	46.3
Run #2 no Air	32.23	47.0	48.9

Where:
Vent Cross Section (7.0" diameter) = 0.267 ft^2
Hood Cross Section (40" x 40")= 11.11 ft^2
Gap Cross Section (8.0" avg. between cover and solution from both 8 ft. ends) = 10.67 ft^2
Vent Velocity is taken from the flow rate calculations
Vertical Velocity = Vent Velocity x 60 s/min x Vent Cross Section / Hood Cross Section
Horizontal Velocity = Vent Vel. x 60 s/min x Vent Cross Section / Gap Cross Section

Air Agitation Rate

To measure the air agitation rate, a five gallon plastic bucket was inverted and submerged to approximately one third of its height into the plating solution to create an air-tight seal at the bucket's perimeter. The bucket was moved across the surface of plating bath as to encompass the average air agitation rate in the tank while maintaining the bucket at a constant submersion height. A tap on the unsubmerged side of the bucket was connected to a calibrated gas meter to measure the volume of air collected in the bucket during which the elapsed time was also recorded. This technique was checked for accuracy in the laboratory by bubbling a known amount of air into the bottom of a water bath. The bucket technique was successful in duplicating the measurement of the gas metered into the bottom of the tank.

The air agitation rate as determined by this method was reported in units of scfm. Since a 60 °F temperature compensated meter was used at atmospheric pressure, the readings were taken at very close to standard conditions. The moisture in the tank was, for the most part, condensed in the line between the bucket and the meter. A residual moisture, however, of approximately 2 - 5% remained in the metered air as it passed through the line. For this reason, the air agitation rate was not reported as a dry flow rate.

TEST CRITIQUE

An effort was made to duplicate the operating conditions of the past MFASC testing to the extent possible. A comparison of the key operational parameters recorded during testing to the past MFASC testing, as well as the past SCAQMD testing is shown in the table below.

Comparison of Key Operation Parameters for the Recent Nickel Plating Tests

Process Parameter	MFASC Test Foss	SCAQMD Test at Foss	SCAQMD Test at California Technical
Plating Current Density	17 amperes/ft^2_{parts}	20 amperes/ft^2_{parts}	23 amperes/ft^2_{parts}
Air Agitation Rate	not able to determine accurately	0.52 acfm/ft^2_{tank} not adjusted from time of MFASC test	0.87 acfm/ft^2_{tank}
Plating Solution Temperature	137-145 °F	132-142 °F	119-124 °F
Plating Solution Nickel Content	10.3 - 12.6 oz/gal	5.9 oz/gal	10.4 oz/gal
Plating Solution Boric Acid Content	5.8 - 8.3 oz/gal	4.0 oz/gal	7.6 oz/gal
Plating Solution pH	3.4 - 4.3	4.8	2.0
Plating Solution Surface Tension	34.2 - 35.9 dynes/cm	47.0 dynes/cm	37.9 dynes/cm
Solution Recirculation	Discharged Above Solution Level	Below Level wo/air Above w/air	Below Level no Bubbling
Number of Drag-Out Events per Run	6	0	6
Capture Technique	High Dilution, High Distance, Low Velocity	Low Dilution, Close Proximity, <50 ft/min	Medium Dilution, Close Proximity, <50 ft/min
Sampling Technique	SCAQMD M1-2, CARB M433	SCAQMD M1-2, CARB M433	SCAQMD M1-2, CARB M433
Duration of Test Runs	120 min	120 min	120 min

The emissions for the non-air agitation runs were higher than the emissions with air agitation. It was expected that the air agitation emissions would be higher than the emissions without the agitation due to the agitation effect as well as observations as stated in SCAQMD Source Test #98-109. The non-air agitation test results were an order of magnitude higher than the past SCAQMD and MFASC tests. During discussions, the MFASC indicated that the increase in non-air agitated emissions was likely due to plating with an unusually low nickel solution concentration causing a low plating efficiency and increased bubbling and nickel emissions. A higher surface bubbling rate was observed during testing as compared to the past SCAQMD testing.

The air agitation run with plating was 17% lower than the air agitation run without plating. Furthermore, the two results are considered as within typical run to run variations from each other. This may suggest that during air agitation, the air agitation is the primary mechanism for the emissions and that the air agitation may partially or completely negate the mechanism for plating emissions. The agitation may have the effect of coalescing with the plating bubbling or perhaps forming larger size bubbling on the surface which masks the effect of the smaller plating bubbling but creates an emission characteristic of its own. It is thought that air agitation will typically result in a net increase in emissions since the agitation is inherently active for a longer period of time than the plating, and since plating emissions can be lower depending on the application.

The measured workplace background concentration for the non-air agitated condition was less than one percent of that measured in the capture vent for emissions sampling. The measured workplace background concentration for the air agitated condition was approximately seven percent of that measured in the capture vent for emissions sampling. Although both sets of test runs each began after an overnight period of non-production to minimize background interference, the air agitation background on the second day of testing was significantly higher than the non-air agitation test. This increase was due primarily to the presence of another nickel tank in the area of the host tank. During the non-air agitation test, this nearby tank did not have a significant effect on the testing since it was not in production during the test period. During the air agitation tests, however, the air agitation in the nearby tank was active. The reason for this was due to the facility's inability to run only one tank with agitation and also to avoid non-normal operation of the host tank. The workplace background samples were positioned in the air steam between the two tanks so that potential contamination would be detected.

Although the air agitation workplace background was significantly higher than that of the non-air agitation test, both are considered as having a very low significance on affecting the emissions measured in this source test.

The blank sample detection was less than one percent of that detected in the emissions samples. The contribution of the blank is therefore considered as having a very low significance on affecting the emissions measured in this source test.

The precision of the sampling as indicated by the consistency of the duplicate sampling results is well within that which is generally experienced and considered acceptable for this type of sampling.

CONCLUSION

The results of the test are considered as both sufficiently accurate and precise for use in determining nickel emission factors. The representativeness of the operating conditions, however, of this or the other tests, is considered as out of the scope of the test reports. This report is limited to the presentation of the data, the operating conditions, observations, and limited comments on typical operation. The selection of the various test results that are considered as typical or suitable for developing an emission factor will also be left to discussion beyond the presentation of the data in the source test reports.

During discussions, the MFASC indicated that the increase in non-air agitated emissions from this test, was likely due to plating with an unusually low nickel solution concentration causing a low plating efficiency resulting in increased bubbling and nickel emissions.

Due to the similarities between emissions with the air agitation run with plating and the air agitation run without plating, the air agitation may be indicated as the primary mechanism for the emissions. This may also indicate that the air agitation may partially or completely negate the mechanism for plating emissions. Furthermore, because of the presumed independence of the air agitation mechanism, the aforementioned MFASC concern regarding low nickel concentration and low plating efficiency is thought to have much less of an effect on the air agitation tests. For this reason, the air agitation results may be considered as more typical than the non-air agitation results.

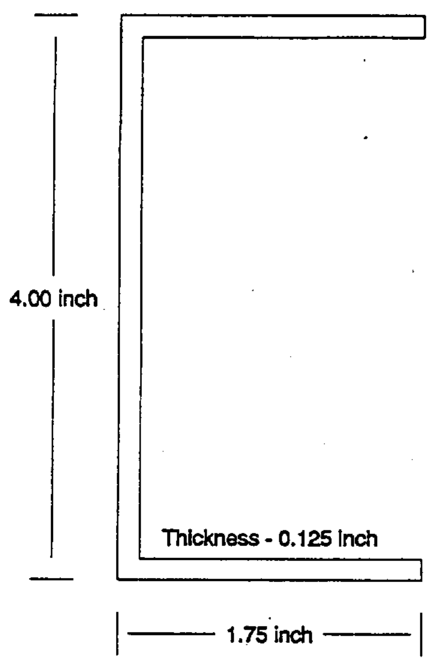
Unlike the other tests in this project, a recommendation on the emission factor in which units would best represent actual emissions will not be made for this report. The reason is that, at the time of this report's issue, further discussion is taking place on which of the data from the various test will be used. Some guidance, however, is given as follows:

If the $lb/hr\text{-}ft^2_{tank}$ factor is used, emissions would be determined by multiplying the factor by ft^2_{tank} as determined using the horizontal internal dimensions of a given tank, and also multiplied by the hours of air agitation for emissions during a specified time period. It is suggested that this factor is not well suited for non-air agitation applications due to the mechanism for the emissions being relatively independent of tank surface area.

If the lb/hr-ft^2_{parts} factor is used, emissions would be determined by multiplying the factor by ft^2_{parts} as determined using the average total surface of parts that are plated in the tank, and also multiplied by the hours of plating during a specified time period. It is suggested that this factor is not well suited for air agitation applications due to the mechanism for the emissions being relatively independent of part surface area.

If the lb/hr-$scfm_{air}$ factor is used, emissions would be determined by multiplying the factor by scfm of air agitation and also multiplied by the hours of air agitation for emissions during a specified time period. If the bucket method is used to determine the air agitation rate, the scfm/ft^2_{tank} result would be multiplied by the ft^2_{tank} as determined using the horizontal internal dimensions of a given tank to determine $scfm_{air}$. This factor would not be appropriate for non-air agitation applications.

Cross Section of Dummy Part Channels



Pieces on Rack #1	Pieces on Rack #2
1 - 4 ft. Length	3 - 6 ft. Lenths
10 - 3 ft. Lengths	9 - 4 ft. Lenths

Total Length of Pieces = 88 ft.

Total Perimeter of Cross Section = 14.75 ft. = 1.23 ft.

Total Surface Area of Parts = 1.23 ft. x 88 ft. = 108.2 sq. ft.

Figure 1 - Dummy Parts

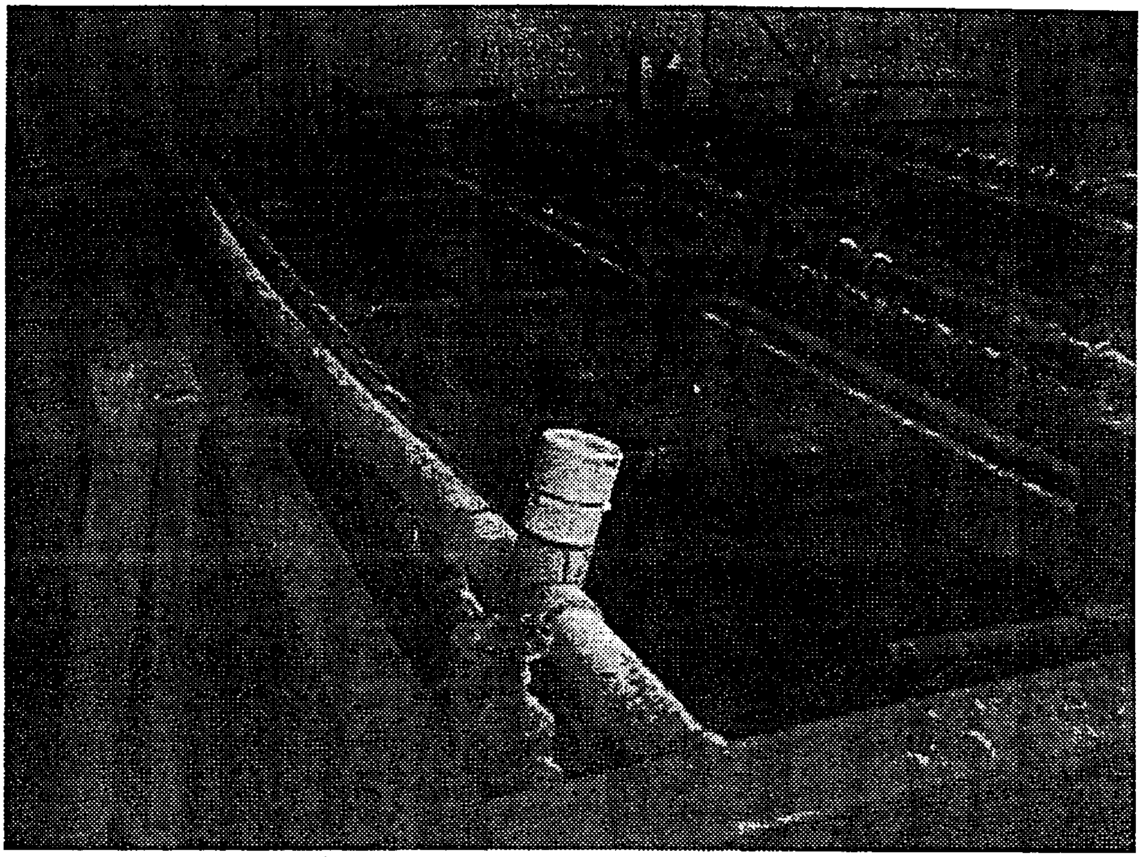


Figure 2 - Photograph of Host Nickel Plating Tank

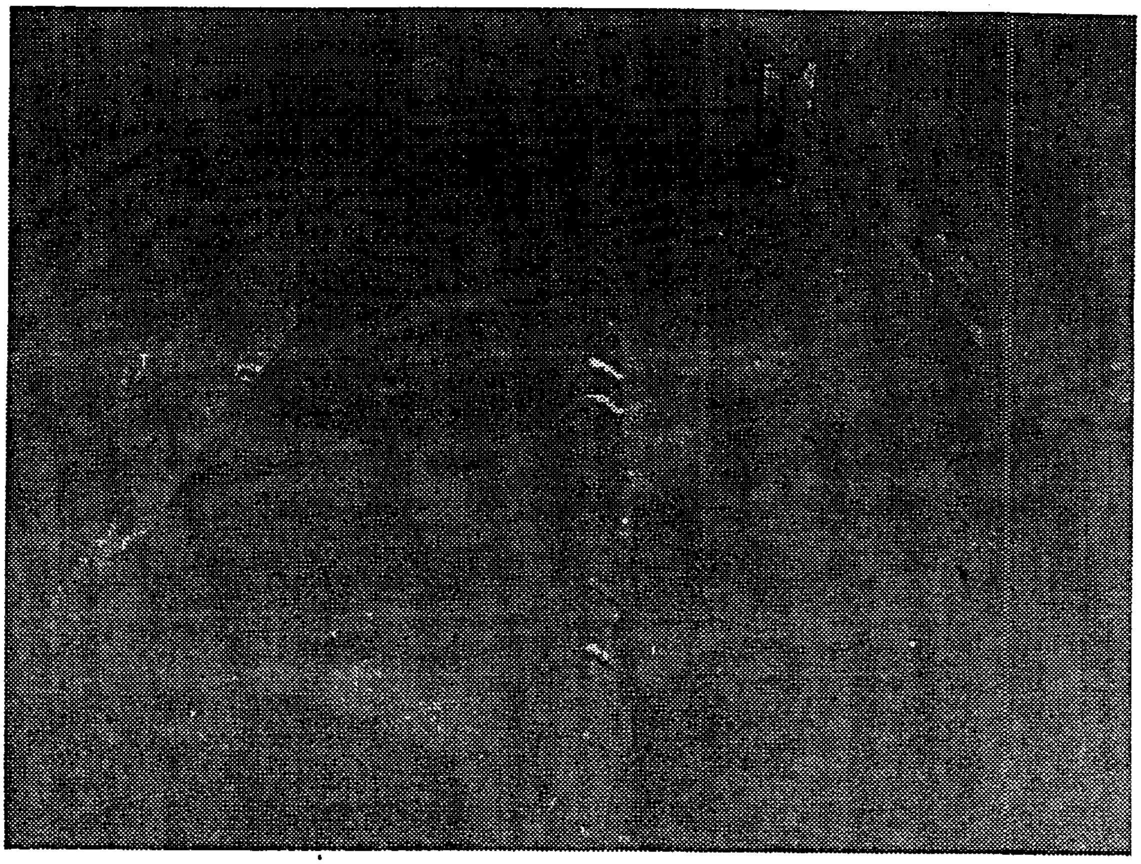


Figure 3 - Photograph of Plating Solution Surface with Air Agitation

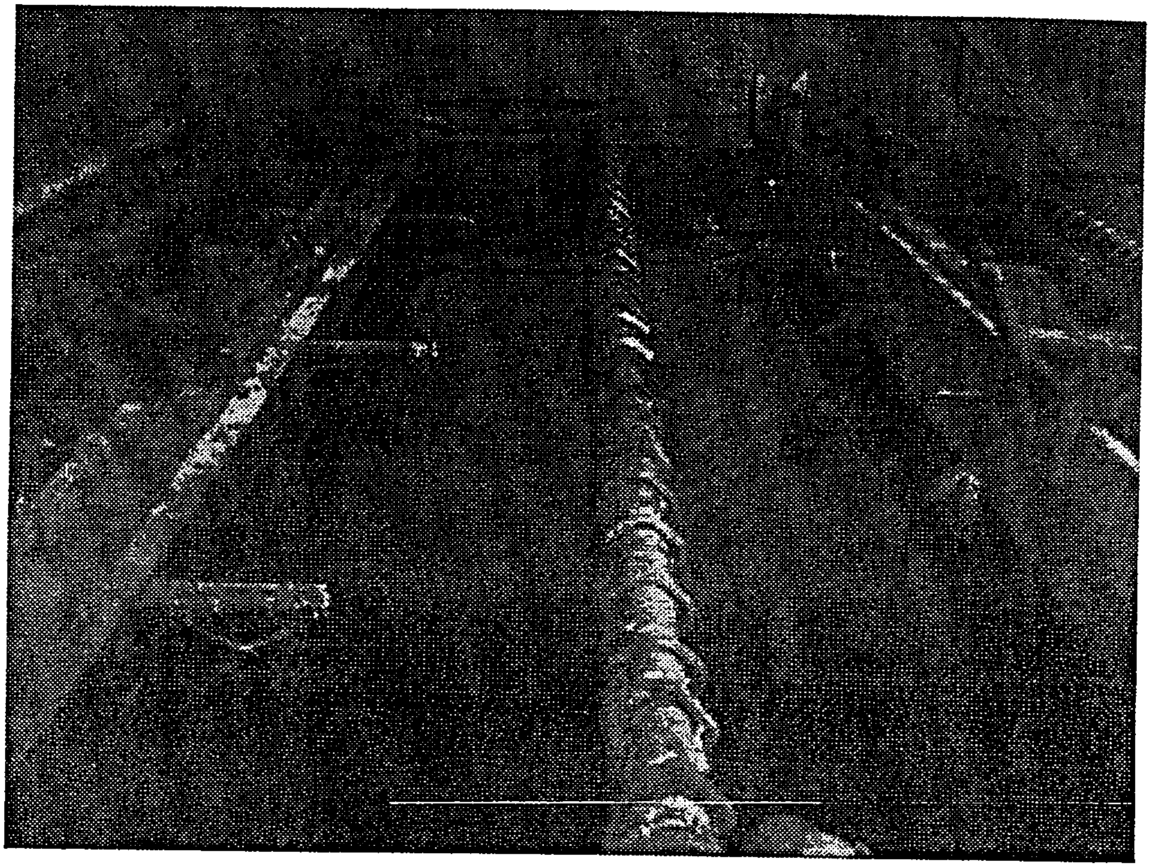


Figure 4 - Photograph of Plating Solution Surface Without Air Agitation

Figure 5 - Close-Up Photograph of Plating Solution Surface with Air Agitation

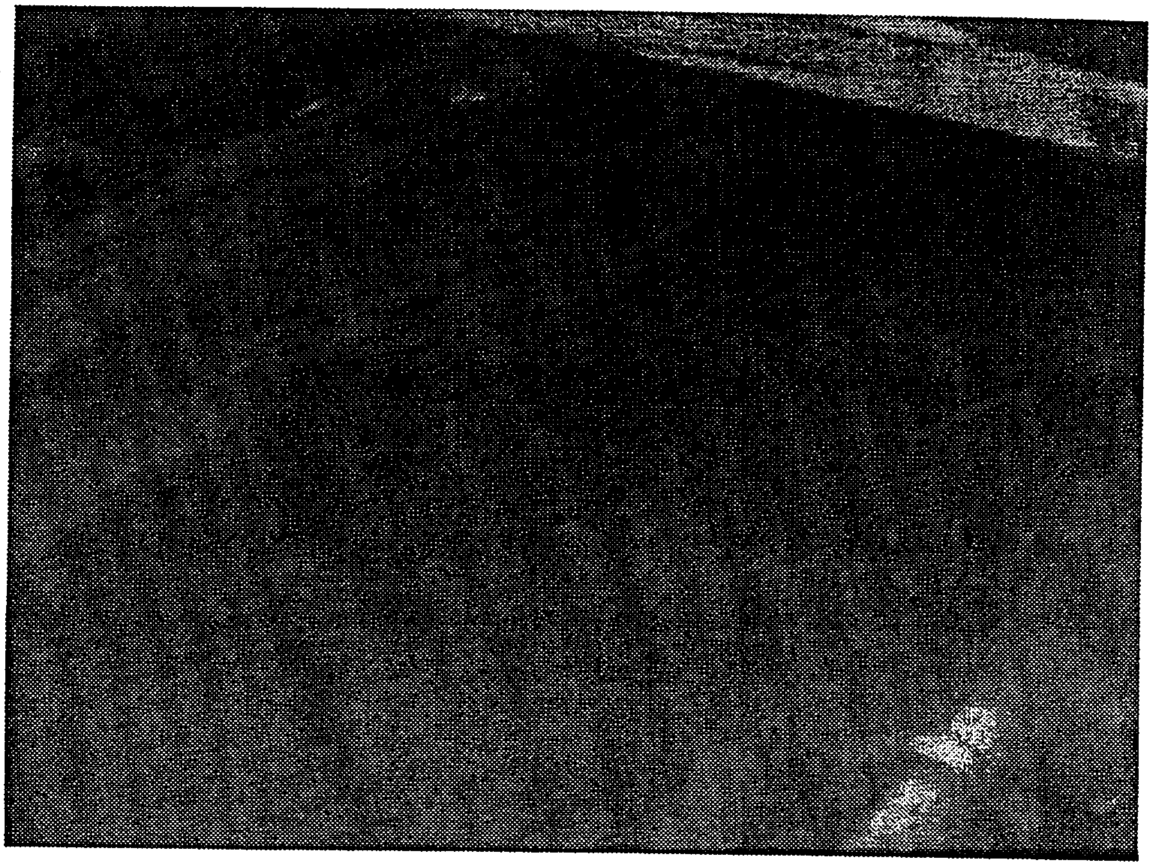


Figure 6 - Close-Up Photograph of Plating Solution Surface Without Air Agitation

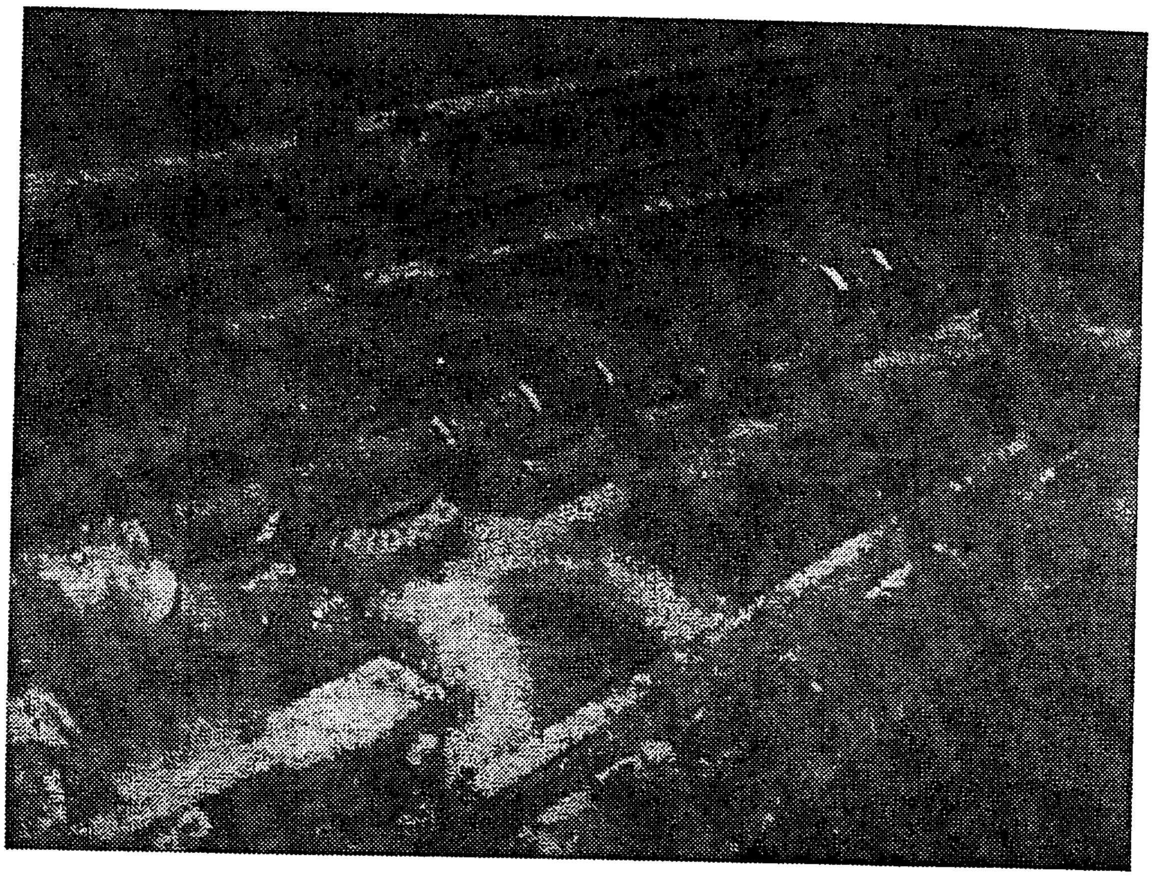


Figure 7 - Photograph of Plating Solution Surface with Air Agitation and Circulation Discharge above Surface

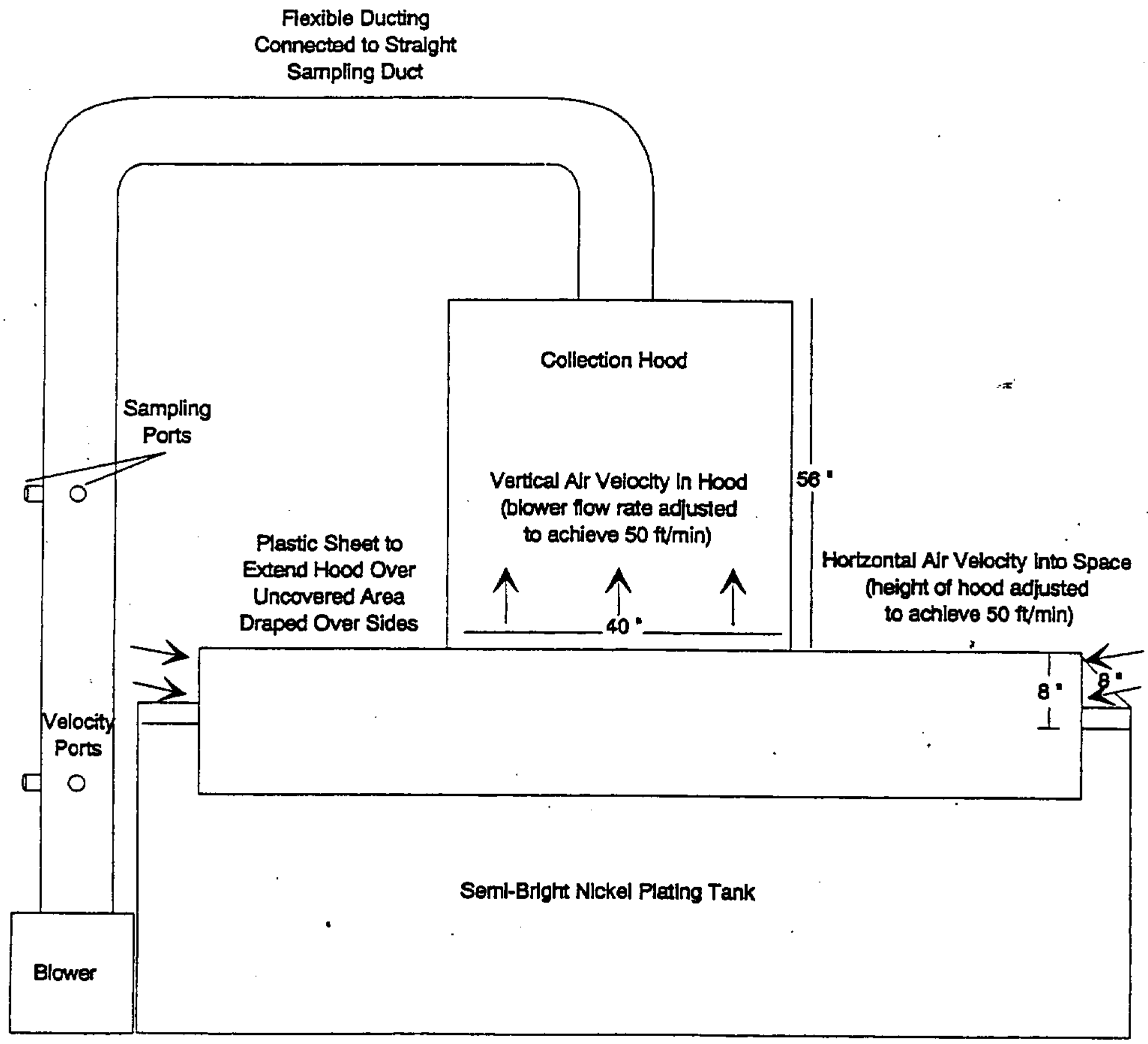


Figure 8 - Temporary Ventilation System with Sampling Location

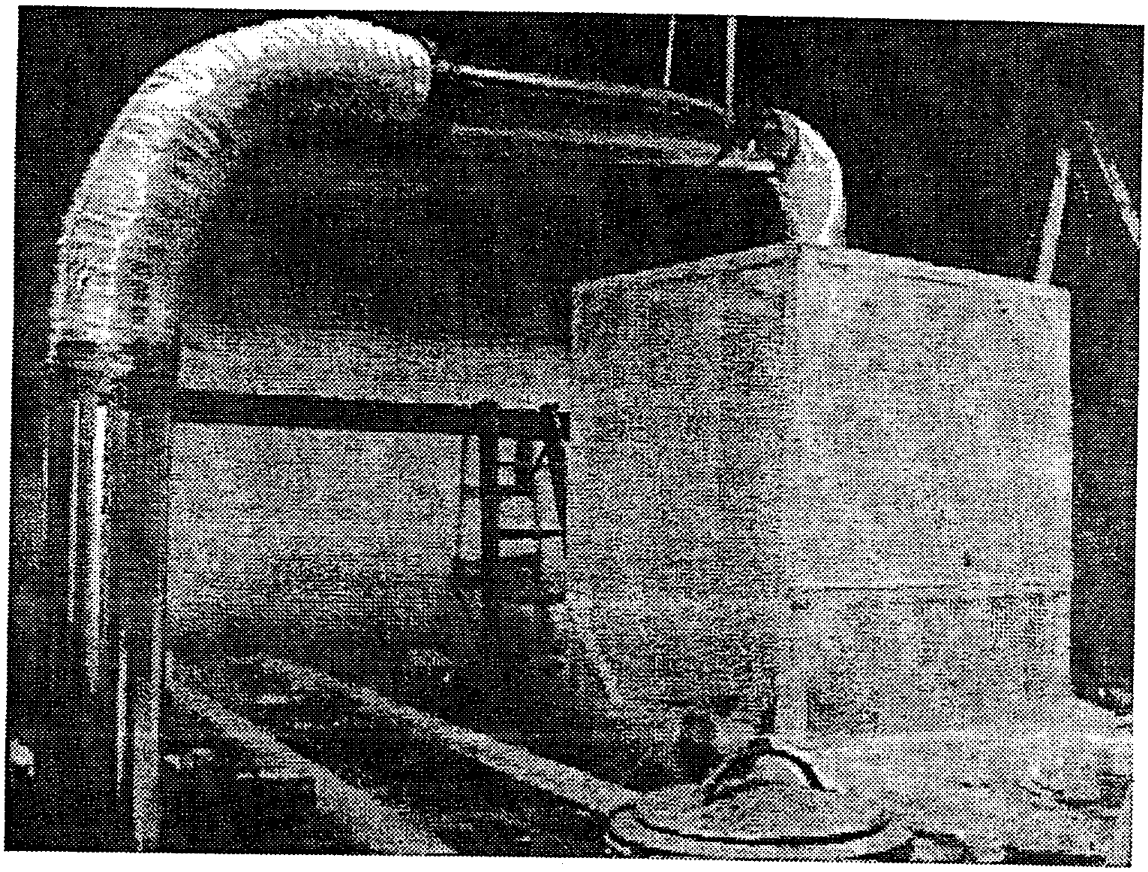
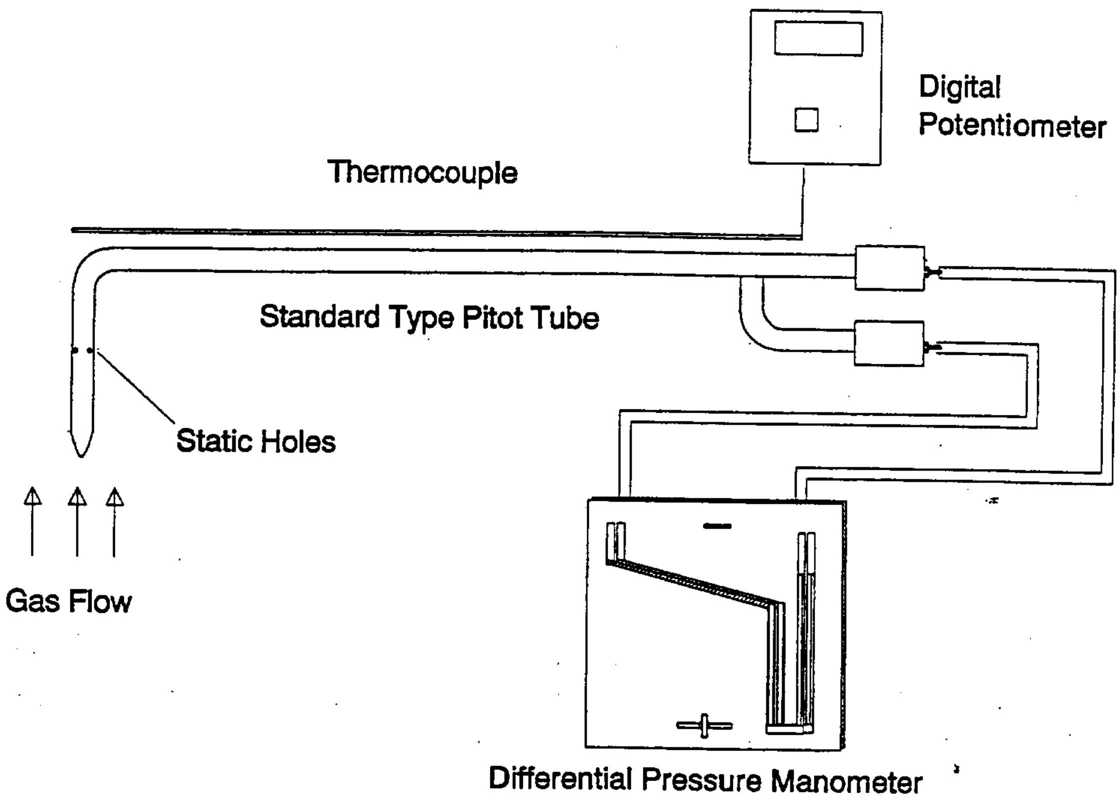
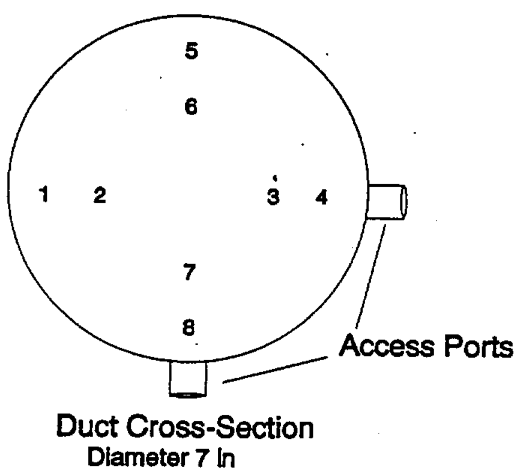


Figure 9 - Photograph of Temporary Ventilation System with Sampling Location





Traverse Point #	Distance from Inner Stack Wall (in)
1, 5	0.5
2, 6	1.75
3, 7	5.25
4, 8	6.5

Figure 10 - Flow Rate Measuring Apparatus

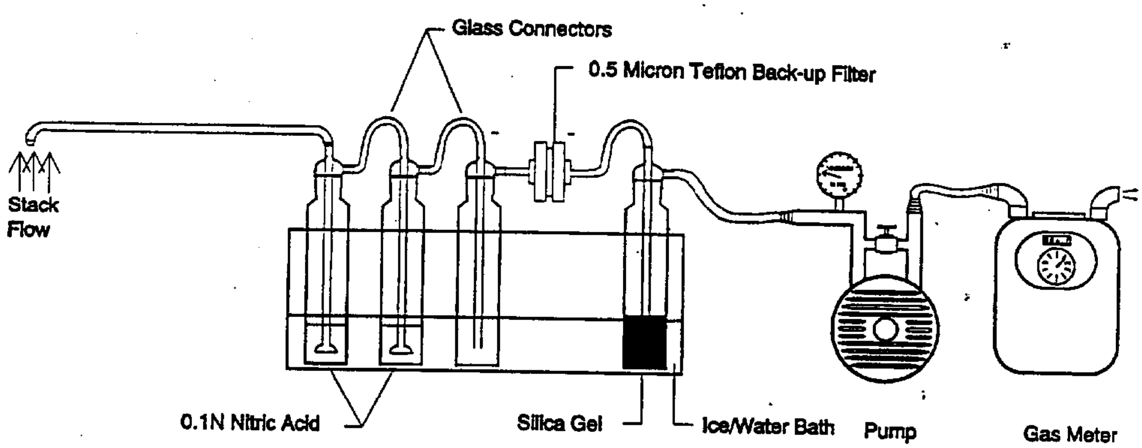
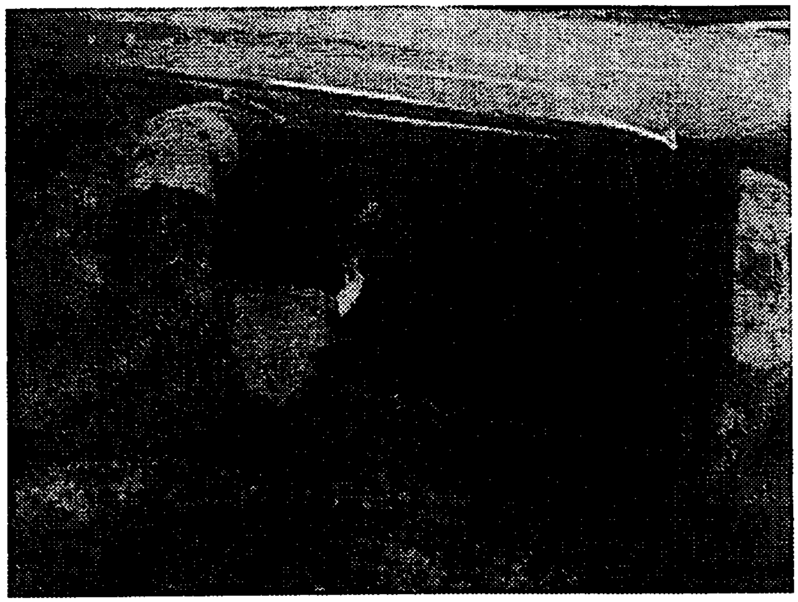


Figure 11 - Nickel Sampling Apparatus



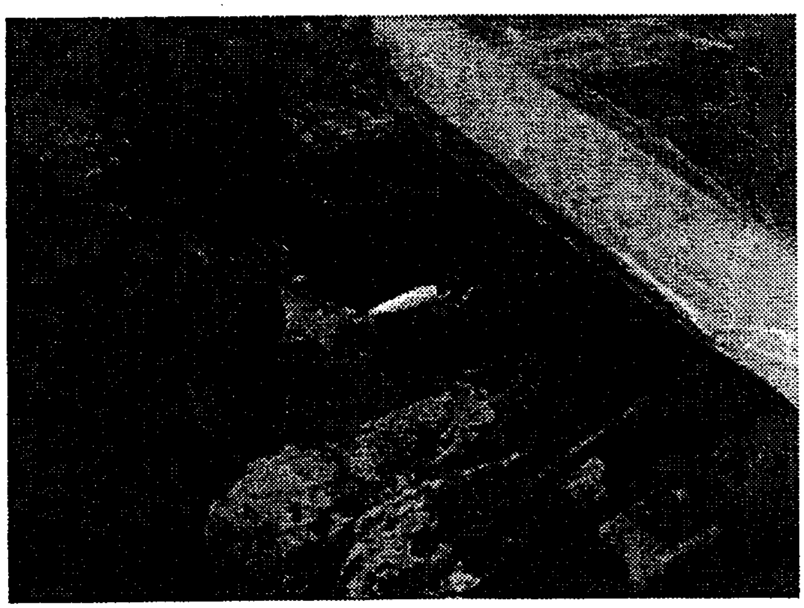


Figure 12 - Photographs of Smoke Test for Capture Efficiency

SOURCE TEST CALCULATIONS

Average Velocity and Temperature

Run #1 with Air Agitation

Traverse Point #	Velocity Head #1 ("H_2O)	Temp. (°F)	Calculated Velocity (fps)
1	0.21	114	31.84
2	0.20	112	31.02
3	0.20	110	30.96
4	0.22	112	32.53
5	0.23	119	33.47
6	0.20	118	31.18
7	0.20	117	31.15
8	0.25	118	34.86
Average Velocity (fps)			32.13
Average Temperature (°F) -		115	

Run #2 with Air Agitation

Traverse Point #	Velocity Head #1 ("H_2O)	Temp. (°F)	Calculated Velocity (fps)
1	0.22	114	32.59
2	0.23	113	33.29
3	0.22	114	32.59
4	0.26	111	35.33
5	0.20	112	31.02
6	0.21	112	31.78
7	0.21	111	31.76
8	0.26	110	35.30
Average Velocity (fps)			32.96
Average Temperature (°F) -			112.125

Where: Calculated Velocity = 2.9 x [Velocity Head x (460 + Temperature)]$^{0.5}$

SOURCE TEST CALCULATIONS

Average Velocity and Temperature

Run #1 No Air Agitation

Traverse Point #	Velocity Head #1 ("H_2O)	Temp. (°F)	Calculated Velocity (fps)
1	0.18	95	28.99
2	0.24	96	33.50
3	0.21	97	31.36
4	0.16	104	27.55
5	0.17	108	28.50
6	0.19	110	30.18
7	0.19	111	30.21
8	0.22	110	32.47
Average Velocity (fps)			30.34
Average Temperature (°F) -			103.875

Run #2 No Air Agitation

Traverse Point #	Velocity Head #1 ("H_2O)	Temp. (°F)	Calculated Velocity (fps)
1	0.21	110	31.73
2	0.25	110	34.62
3	0.21	112	31.78
4	0.22	111	32.50
5	0.23	114	33.32
6	0.21	115	31.87
7	0.18	111	29.40
8	0.20	109	30.94
Average Velocity (fps)			32.02
Average Temperature (°F) -			111.5

Where: Calculated Velocity = 2.9 x [Velocity Head x (460 + Temperature)]$^{0.5}$

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SOURCE TEST CALCULATIONS
Flow Rate and Emissions for Run #1 with Air Agitation

Sample Train: Nickel Train #3

Input by: M.Garibay

SUMMARY

A. Average Traverse Velocity........ 32.13 fps
B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters)........ 92 deg F
C. Gas Meter Correction Factor........ 1.0023
D. Average Orifice Pressure........ 1.09 "H20
E. Nozzle Diameter........ 0.2473 inch

F1. Stack Dimension #1........ 7 inch
F2. Stack Dimension #2........ inch
G. Stack Cross Sect. Area........ 0.267 ft2
H. Average Stack Temp........ 115.0 deg F
I. Barometric Pressure........ 29.92 "HgA
J. Gas Meter Pressure (I+(D/13.6 30.00 "HgA
K. Static Pressure........ -0.57 "H20
L. Total Stack Pressure (I+(K/13. 29.88 "HgA

M. Pitot Correction Factor........ 1.00
N. Sampling Time........ 120 min
O. Nozzle X-Sect. Area........ 0.00033 ft
P. Sample Collection........ 1.17 mg
Q. Sample Collection........ 1.17 mg
R. Water Vapor Condensed........ 109 ml
S. Gas Volume Metered........ 70.153 dcf

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C........ 66.416 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T))........ 7.08 %

V. Average Molecular Weight (Wet):

Component	Vol. Fract.		x Moist. Fract.	x Molecular Wt.	= Wt./
Water	0.071		1.000	18.0	1.27
Carbon Dioxide	0.000	Dry Basis	0.929	44.0	0.02
Carbon Monoxide	0.000	Dry Basis	0.929	28.0	0.00
Oxygen	0.209	Dry Basis	0.929	32.0	6.21
Nitrogen & Inerts	0.791	Dry Basis	0.929	28.2	20.72
				Sum	28.22

FLOW RATE

W. Gas Density Correction Factor (28.95/V)^.5........ 1.01
X. Velocity Pressure Correction Factor (29.92/L)^.5........ 1.00
Y. Corrected Velocity (A x M x W x X)........ 32.56 fps
Z. Flow Rate (Y x G x 60)........ 522 cfm
AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]}........ 472 scfm
BB. Dry Flow Rate (AA x (U/100))........ 438 dscfm

SAMPLE CONCENTRATION/EMISSION RATE

CC. Sample Concentration [0.01543 x (P/T)]........ 2.72E-04 gr/dscf
DD. Sample Conc. [54,143xCC/ 58.7 (Molecular Wt.)]........ 0.25072 ppm
EE. Nickel Emission Rate (0.00857 x BB xCC)........ 1.02E-03 lb/hr
FF. Nickel Emission Rate [(.0001322 x Q x BB)/T]........ 1.02E-03 lb/hr
GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)]........ 101.2 %

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SOURCE TEST CALCULATIONS
Flow Rate and Emissions for Run #2 with Air Agitation

Sample Train: Nickel Train #7 Input by: M.Garibay

SUMMARY

A. Average Traverse Velocity	32.96	fps
B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters)	99	deg F
C. Gas Meter Correction Factor	1.0023	
D. Average Orifice Pressure	1.09	"H20
E. Nozzle Diameter	0.2435	inch

F1. Stack Dimension #1	.7	inch			
F2. Stack Dimension #2		inch	M. Pitot Correction Factor	1.00	
G. Stack Cross Sect. Area	0.267	ft2	N. Sampling Time	120	min
H. Average Stack Temp	112.0	deg F	O. Nozzle X-Sect. Area	0.00032	ft
I. Barometric Pressure	29.92	"HgA	P. Sample Collection	1.35	mg
J. Gas Meter Pressure (I+(D/13.6	30.00	"HgA	Q. Sample Collection	1.35	mg
K. Static Pressure	-0.57	"H20	R. Water Vapor Condensed	93.1	ml
L. Total Stack Pressure (I+(K/13.	29.88	"HgA	S. Gas Volume Metered	70.728	dcf

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C .... 66.121 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) .... 6.13 %

V. Average Molecular Weight (Wet):

Component	Vol. Fract.		x	Moist. Fract.	x	Molecular Wt.	=	Wt./
Water	0.061			1.000		18.0	,	1.10
Carbon Dioxide	0.000	Dry Basis		0.939		44.0	,	0.02
Carbon Monoxide	0.000	Dry Basis		0.939		28.0	,	0.00
Oxygen	0.209	Dry Basis		0.939		32.0	,	6.28
Nitrogen & Inerts	0.791	Dry Basis		0.939		28.2	,	20.93
						Sum		28.33

FLOW RATE

W. Gas Density Correction Factor (28.95/V)^.5	1.01	
X. Velocity Pressure Correction Factor (29.92/L)^.5	1.00	
Y. Corrected Velocity (A x M x W x X)	33.34	fps
Z. Flow Rate (Y x G x 60)	535	cfm
AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]}	485	scfm
BB. Dry Flow Rate (AA x (U/100))	456	dscfm

SAMPLE CONCENTRATION/EMISSION RATE

CC. Sample Concentration [0.01543 x (P/T)]	3.15E-04	gr/dscf
DD. Sample Conc. [54,143xCC/ 58.7 (Molecular Wt.)]	0.29058	ppm
EE. Nickel Emission Rate (0.00857 x BB xCC)	1.23E-03	lb/hr
FF. Nickel Emission Rate [(.0001322 x Q x BB)/T]	1.23E-03	lb/hr
GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)]	99.9	%

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SOURCE TEST CALCULATIONS
Emissions for Ambient with Air Agitation

Sample Train: Nickel Train #4 Input by: M.Garibay

SUMMARY

A. Average Traverse Velocity		fps
B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters)	100	deg F
C. Gas Meter Correction Factor	1.0042	
D. Average Orifice Pressure	2.10	"H20
E. Nozzle Diameter		inch

F1. Stack Dimension #1		inch			
F2. Stack Dimension #2		inch	M. Pitot Correction Factor		
G. Stack Cross Sect. Area		ft2	N. Sampling Time	285	min
H. Average Stack Temp		deg F	O. Nozzle X-Sect. Area		ft
I. Barometric Pressure	29.92	"HgA	P. Sample Collection	0.306	mg
J. Gas Meter Pressure (I+(D/13.6	30.07	"HgA	Q. Sample Collection	0.306	mg
K. Static Pressure		"H20	R. Water Vapor Condensed	71.4	ml
L. Total Stack Pressure (I+(K/13.		"HgA	S. Gas Volume Metered	228.859	dcf

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C .... 214.506 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) .... 1.52 %

V. Average Molecular Weight (Wet):

Component	Vol. Fract.		x Moist. Fract.	x Molecular Wt.	= Wt./
Water	0.015		1.000	18.0	0.27
Carbon Dioxide	0.000	Dry Basis	0.985	44.0	0.02
Carbon Monoxide	0.000	Dry Basis	0.985	28.0	0.00
Oxygen	0.209	Dry Basis	0.985	32.0	6.59
Nitrogen & Inerts	0.791	Dry Basis	0.985	28.2	21.96
				Sum	28.83

FLOW RATE

W. Gas Density Correction Factor (28.95/V)^.5	1.00	
X. Velocity Pressure Correction Factor (29.92/L)^.5		
Y. Corrected Velocity (A x M x W x X)		fps
Z. Flow Rate (Y x G x 60)		cfm
AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]}		scfm
BB. Dry Flow Rate (AA x (U/100))		dscfm

SAMPLE CONCENTRATION/EMISSION RATE

CC. Sample Concentration [0.01543 x (P/T)]	2.20E-05	gr/dscf
DD. Sample Conc. [54,143xCC/ 58.7 (Molecular Wt.)]	0.02030	ppm
EE. Nickel Emission Rate (0.00857 x BB xCC)		lb/hr
FF. Nickel Emission Rate [(.0001322 x Q x BB)/T]		lb/hr
GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)]		%

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SOURCE TEST CALCULATIONS
Flow Rate and Emissions for Run #1 No Air Agitation

Sample Train: Nickel Train #2 Input by: M.Garibay

SUMMARY

A. Average Traverse Velocity	30.34	fps
B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters)	95	deg F
C. Gas Meter Correction Factor	1.0023	
D. Average Orifice Pressure	2.67	"H20
E. Nozzle Diameter	0.3125	inch

F1. Stack Dimension #1	7	inch			
F2. Stack Dimension #2		inch	M. Pitot Correction Factor	1.00	
G. Stack Cross Sect. Area	0.267	ft2	N. Sampling Time	120	min
H. Average Stack Temp	104.0	deg F	O. Nozzle X-Sect. Area	0.00053	ft
I. Barometric Pressure	30.00	"HgA	P. Sample Collection	2.95	mg
J. Gas Meter Pressure (I+(D/13.6	30.20	"HgA	Q. Sample Collection	2.95	mg
K. Static Pressure	-0.50	"H20	R. Water Vapor Condensed	79.4	ml
L. Total Stack Pressure (I+(K/13.	29.96	"HgA	S. Gas Volume Metered	110.584	dcf

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C .... 104.808 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) .... 3.40 %

V. Average Molecular Weight (Wet):

Component	Vol. Fract.		x Moist. Fract.	x Molecular Wt.	= Wt./
Water	0.034		1.000	18.0	0.61
Carbon Dioxide	0.000	Dry Basis	0.966	44.0	0.02
Carbon Monoxide	0.000	Dry Basis	0.966	28.0	.0.00
Oxygen	0.209	Dry Basis	0.966	32.0	6.46
Nitrogen & Inerts	0.791	Dry Basis	0.966	28.2	21.54
				Sum	28.63

FLOW RATE

W. Gas Density Correction Factor (28.95/V)^.5	1.01	
X. Velocity Pressure Correction Factor (29.92/L)^.5	1.00	
Y. Corrected Velocity (A x M x W x X)	30.49	fps
Z. Flow Rate (Y x G x 60)	489	cfm
AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]}	451	scfm
BB. Dry Flow Rate (AA x (U/100))	436	dscfm

SAMPLE CONCENTRATION/EMISSION RATE

CC. Sample Concentration [0.01543 x (P/T)]	4.34E-04	gr/dscf
DD. Sample Conc. [54,143xCC/ 58.7 (Molecular Wt.)]	0.40059	ppm
EE. Nickel Emission Rate (0.00857 x BB xCC)	1.62E-03	lb/hr
FF. Nickel Emission Rate [(.0001322 x Q x BB)/T]	1.62E-03	lb/hr
GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)]	100.5	%

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SOURCE TEST CALCULATIONS
Flow Rate and Emissions for Run #2 No Air Agitation

Sample Train: Nickel Train #6 Input by: M.Garibay

SUMMARY

A. Average Traverse Velocity	32.02	fps
B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters)	103	deg F
C. Gas Meter Correction Factor	1.0023	
D. Average Orifice Pressure	3.14	"H20
E. Nozzle Diameter	0.3168	inch

F1. Stack Dimension #1	7	inch			
F2. Stack Dimension #2		inch	M. Pitot Correction Factor	1.00	
G. Stack Cross Sect. Area	0.267	ft2	N. Sampling Time	120	min
H. Average Stack Temp	112.0	deg F	O. Nozzle X-Sect. Area	0.00055	ft
I. Barometric Pressure	30.00	"HgA	P. Sample Collection	3.60	mg
J. Gas Meter Pressure (I+(D/13.6	30.23	"HgA	Q. Sample Collection	3.60	mg
K. Static Pressure	-0.50	"H20	R. Water Vapor Condensed	107.6	ml
L. Total Stack Pressure (I+(K/13.	29.96	"HgA	S. Gas Volume Metered	120.657	dcf

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C .... 112.859 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) .... 4.24 %

V. Average Molecular Weight (Wet):

Component	Vol. Fract.		x	Moist. Fract.	x	Molecular Wt.	=	Wt./
Water	0.042			1.000		18.0	,	0.76
Carbon Dioxide	0.000	Dry Basis		0.958		44.0	,	0.02
Carbon Monoxide	0.000	Dry Basis		0.958		28.0	,	0.00
Oxygen	0.209	Dry Basis		0.958		32.0	,	6.40
Nitrogen & Inerts	0.791	Dry Basis		0.958		28.2	,	21.35
						Sum		28.53

FLOW RATE

W. Gas Density Correction Factor (28.95/V)^.5	1.01	
X. Velocity Pressure Correction Factor (29.92/L)^.5	1.00	
Y. Corrected Velocity (A x M x W x X)	32.23	fps
Z. Flow Rate (Y x G x 60)	517	cfm
AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]}	470	scfm
BB. Dry Flow Rate (AA x (U/100))	451	dscfm

SAMPLE CONCENTRATION/EMISSION RATE

CC. Sample Concentration [0.01543 x (P/T)]	4.92E-04	gr/dscf
DD. Sample Conc. [54,143xCC/ 58.7 (Molecular Wt.)]	0.45398	ppm
EE. Nickel Emission Rate (0.00857 x BB xCC)	1.90E-03	lb/hr
FF. Nickel Emission Rate [(.0001322 x Q x BB)/T]	1.90E-03	lb/hr
GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)]	101.9	%

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SOURCE TEST CALCULATIONS
Emissions for Ambient No Air Agitation

Sample Train: Nickel Train #5 Input by: M.Garibay

SUMMARY

A. Average Traverse Velocity		fps
B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters)	100	deg F
C. Gas Meter Correction Factor	1.0042	
D. Average Orifice Pressure	2.10	"H20
E. Nozzle Diameter		inch

F1. Stack Dimension #1		inch			
F2. Stack Dimension #2		inch	M. Pitot Correction Factor		
G. Stack Cross Sect. Area		ft2	N. Sampling Time	285	min
H. Average Stack Temp		deg F	O. Nozzle X-Sect. Area		ft
I. Barometric Pressure	30.00	"HgA	P. Sample Collection	0.0325	mg
J. Gas Meter Pressure (I+(D/13.6	30.15	"HgA	Q. Sample Collection	0.0325	mg
K. Static Pressure		"H20	R. Water Vapor Condensed	52.5	ml
L. Total Stack Pressure (I+(K/13.		"HgA	S. Gas Volume Metered	229.173	dcf

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C .... 215.372 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) .... 1.12 %

V. Average Molecular Weight (Wet):

Component	Vol. Fract.	x	Moist. Fract.	x	Molecular Wt.	=	Wt./
Water	0.011		1.000		18.0	,	0.20
Carbon Dioxide	0.000	Dry Basis	0.989		44.0	,	0.02
Carbon Monoxide	0.000	Dry Basis	0.989		28.0	,	0.00
Oxygen	0.209	Dry Basis	0.989		32.0	,	6.61
Nitrogen & Inerts	0.791	Dry Basis	0.989		28.2	,	22.05
						Sum	28.88

FLOW RATE

W. Gas Density Correction Factor (28.95/V)^.5	1.00	
X. Velocity Pressure Correction Factor (29.92/L)^.5		
Y. Corrected Velocity (A x M x W x X)		fps
Z. Flow Rate (Y x G x 60)		cfm
AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]}		scfm
BB. Dry Flow Rate (AA x (U/100))		dscfm

SAMPLE CONCENTRATION/EMISSION RATE

CC. Sample Concentration [0.01543 x (P/T)]	2.33E-06	gr/dscf
DD. Sample Conc. [54,143xCC/ 58.7 (Molecular Wt.)]	0.00215	ppm
EE. Nickel Emission Rate (0.00857 x BB xCC)		lb/hr
FF. Nickel Emission Rate [(.0001322 x Q x BB)/T]		lb/hr
GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)]		%

South Coast
Air Quality Management District
21865 E. Copley Drive, Diamond Bar, CA 91765-4182 (909) 396-2000

SOURCE TEST CALCULATIONS
Results with Calculation Footnotes

Run #	lb/hr	lb/hr-ft2 tank	lb/hr-ft2 parts	lb/hr-cfmair	gr/dscf	mg/dscm	mg/hr	amperes	mg/A-hr
1 air	1.02E-03	1.06E-05	9.43E-06	2.04E-05	2.72E-04	0.622	463	2162	0.214
2 air	1.23E-03	1.28E-05	1.14E-05	2.46E-05	3.15E-04	0.721	558	N/A	N/A
Average	1.13E-03	1.17E-05	1.04E-05	2.25E-05	2.94E-04	0.672	510	2162	0.214
Ambient	N/A	N/A	N/A	N/A	2.20E-05	0.0503	N/A	N/A	N/A
1 no air	1.62E-03	1.69E-05	1.50E-05	N/A	4.34E-04	0.993	735	2159	0.340
2 no air	1.90E-03	1.98E-05	1.76E-05	N/A	4.92E-04	1.126	862	2162	0.399
Average	1.76E-03	1.83E-05	1.63E-05	N/A	4.63E-04	1.059	798	2161	0.369
Ambient	N/A	N/A	N/A	N/A	2.33E-06	0.00533	N/A	N/A	N/A

Where:

Surface Area of Tank Solution = 96 ft2
Surface Area of Parts = 108.2 ft2
Air Agitation Rate Run #1 = 0.52 cfm/ft2tank
Air Agitation Rate Run #2 = 0.52 cfm/ft2tank
lb/hr is from the Flow Rate and Mass Emission Rate Spreadsheet
lb/hr-ft2 tank = lb/hr / Surface Area of Tank Solution
lb/hr-ft2 parts = lb/hr / Surface Area of Parts
lb/hr-cfmair = lb/hr-ft2tank / Air Agitation Rate per ft2tank
gr/dscf is from the Flow Rate and Mass Emission Rate Spreadsheet
mg/dscm = gr/dscf*2288.3
mg/hr = lb/hr x 453592
amperes is the average plating amperage during testing period from A-hr meter (A-hr/hr)
mg/A-hr = mg/hr / average plating amperage during testing period

APPENDIX

Field Data, Calibration Data, and Laboratory Results

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-112 | Date: 10/24/98
Sampling Location: Foss Plating RUN #1 - NO AIR | Sample Train #2

TRAVERSE SOURCE TEST DATA

K=0.567

Pre-Test Leak Check:
Filter ____ cfm @ ____ "Hg vac
Probe 0.003 cfm @ 15 "Hg vac
(Pitot Tube Leak Check ✓)

Post-Test Leak Check:
Filter ____ cfm @ ____ "Hg vac
Probe 0.002 cfm @ 8 "Hg vac
(Pitot Tube Leak Check ✓)

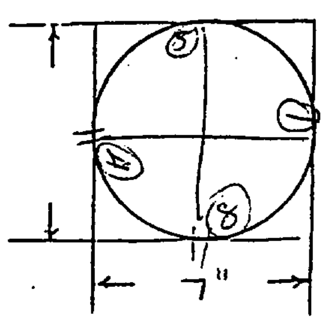
Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Velocity Head ("H_2O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Calculated Orifice ΔP ("H_2O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vac "Hg
12:10			091.221										
	+15	1	103.4	0.18	92	28.98	0.841	2.39			85	82	6
	+30	2	118.1	0.24	96	33.49	0.970	3.20			84	83	8
	+45	3	133.4	0.21	97	31.36	0.906	2.85			92	85	8
	+60	4	147.4	0.16	104	27.54	0.756	2.21			105	93	7
	+15	5	159.4	0.17	108	28.49	0.807	2.35			102	96	6
	+30	6	173.1	0.14	110	30.17	0.852	2.61			102	96	6
	+45	7	188.8	0.19	111	30.21	0.851	2.65			107	98	6
	+60	8	201.805	0.22	110	32.47	0.917	3.10			110	102	8
											95		
(Net Vol. Uncorr.)				Avg.	104	30.34		2.67	/		/		

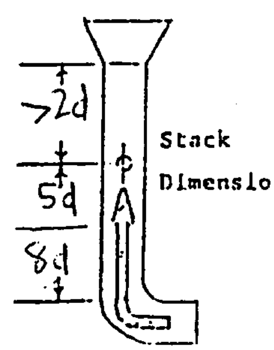
...pped ...t at ...34pm ...e to ...ting re-...cting ...tion ...me ...ter ...ting ...3:44 ...rted ...t at 3pm

Nozzle #
Nozzle Diameter ____ mm (0.2125 ")
Barometric Pressure 30.00 "HgA
Static Pressure in Stack.................... ____ "HgA (+/-) 0.50 "H_2O
Recorded By C.W
Pitot Factor.................... 1.00

Calibration Data

Inclined Manometer	N07Y1	(Cal: N/A)
Magnehelic No.	N/A	(Cal: N/A)
Pitot Tube No.	NIST	(Cal: 2/12/98)
Potentiometer No.	N0314	(Cal: 10/21/98)
Thermocouple No.	20113	(Cal: 10/21/98)
Gas Meter No.	N0714	(Cal: 10/21/98)
Meter Corr. Factor:	1.0023	





Type Sampling Probe Glass

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-112
Sampling Location: Foss Plating RUN#2 NO AIR

Date: 10/29/98
Sample Train #6

TRAVERSE SOURCE TEST DATA

Pre-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.007 cfm @ 15 "Hg vac
(Pitot Tube Leak Check ✓)

K = 0.567

Post-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.007 cfm @ 5 "Hg vac
(Pitot Tube Leak Check ✓)

Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Velocity Head ("H_2O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Calculated Orifice ΔP ("H_2O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vacuum "Hg
			203.174										
	+15	1	217.6	0.21	110	31.73	0.921	3.06			94	100	4
	+30	2	233.6	0.25	108	34.61	1.005	3.65			102	100	5
	+45	3	248.9	0.21	112	31.78	0.919	3.11			109	101	5
	+60	4	264.3	0.22	111	32.50	0.942	3.28			112	102	5
	+15	5	279.5	0.23	114	33.32	0.961	3.38			106	104	5
	+30	6	294.8	0.21	115	31.80	0.917	3.06			105	101	5
	+45	7	308.9	0.15	111	29.40	0.852	2.66			106	102	5
	+60	8	323.831	0.20	104	30.93	0.899	2.95			105	101	5
			SWITCHED	FILTER	WITH	TRAIN	#10						
											103		
(Net Vol. Uncorr.)				Avg.	112	32.02		3.14					

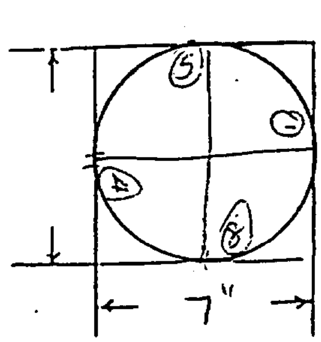
Nozzle #
Nozzle Diameter ______ mm (0.3168 ")
Barometric Pressure 30.00 "HgA
Static Pressure in Stack ______ "HgA (+/- 0.50 "H_2O)

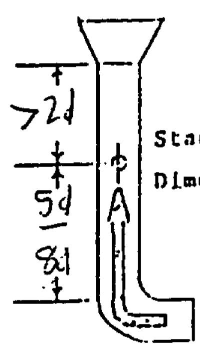
Recorded By C.W.
Pitot Factor 1.00

Calibration Data

Inclined Manometer N0714	(Cal: N/A)
Magnehelic No. N/A	(Cal: N/A)
Pitot Tube No. NIST	(Cal: 2/12/98)
Potentiometer No. N°314	(Cal: 10/21/98)
Thermocouple No. 20113	(Cal: 10/21/98)
Gas Meter No. N0714	(Cal: 2/21/98)
Meter Corr. Factor: 1.0023	

Type Sampling Probe Glass





Stack Dimension

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-112
Date: 10/25/98
Sampling Location: Foss Plating RUN#3 WITH AIR
Sample Train #3

TRAVERSE SOURCE TEST DATA

K= 0.567

Pre-Test Leak Check:
Filter ____ cfm @ ____ "Hg vac
Probe 0.001 cfm @ 15 "Hg vac
(Pitot Tube Leak Check ✓)

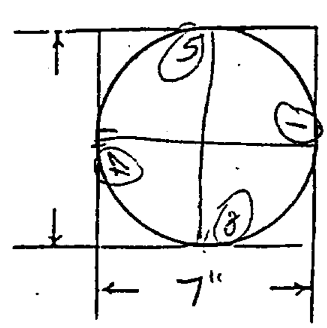
Post-Test Leak Check:
Filter ____ cfm @ ____ "Hg vac
Probe 0.001 cfm @ 5 "Hg vac
(Pitot Tube Leak Check ✓)

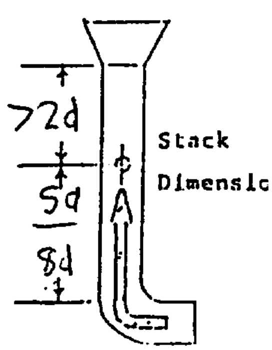
Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Velocity Head ("H_2O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Calculated Orifice ΔP ("H_2O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vac "Hg
10:44			324.022										
	+15	1	333.4	0.21	114	31.83	0.559	1.06			85	85	5
	+30	2	341.9	0.20	112	31.01	0.546	1.02			88	85	5
	+45	3	350.4	0.20	110	30.96	0.547	1.03			90	86	5
	+60	4	358.9	0.22	112	32.53	0.573	1.13			95	89	5
359.04													
k Chek	+15	5	367.8	0.23	119	33.46	0.570	1.15			95	93	5
ore	+30	6	376.5	0.20	118	31.18	0.532	1.00			95	93	5
ting	+45	7	385.3	0.20	117	31.15	0.533	1.01			100	95	5
	+60	8	394.315	0.25	118	34.86	0.595	1.27			102	96	5
and													
rt.													
											92		
(Net Vol. Uncorr.)				Avg.	115	32.13		1.09	✓		✓		

Nozzle #
Nozzle Diameter ____ mm (0.2473 ")
Recorded By C.W.
Barometric Pressure 29.92 "HgA
Pitot Factor........................ 1.00
Static Pressure in Stack........................ ____ "HgA (+) 0.57 "H_2O

Calibration Data

Inclined Manometer	N0714	(Cal: N/A)
Magnehelic No.	N/A	(Cal: N/A)
Pitot Tube No.	NIST	(Cal: 2/12/98)
Potentiometer No.	N0314	(Cal: 10/21/98)
Thermocouple No.	20113	(Cal: 10/21/98)
Gas Meter No.	N0714	(Cal: 10/21/98)
Meter Corr. Factor:	1.0023	





Type Sampling Probe Glass

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-112
Date: 10/25/98
Sampling Location: Foss Plating RUNNING WITH AIR
Sample Train #7

TRAVERSE SOURCE TEST DATA

Pre-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.003 cfm @ 15 "Hg vac
(Pitot Tube Leak Check ✓)

K = 0.567

Post-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.000 cfm @ 5 "Hg vac
(Pitot Tube Leak Check ✓)

Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Velocity Head ("H2O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Calculated Orifice ΔP ("H2O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vacuum "Hg
1:15pm			394.597		~~113~~								
	+15	1	403.1	0.22	114	32.58	0.543	1.05			98	97	4
	+30	2	411.8	0.23	113	33.29	0.556	1.10			97	97	4
	+45	3	420.7	0.22	114	32.58	0.543	1.06			101	98	4
	+60	4	430.4	0.26	111	35.33	0.592	1.27			103	98	5
	+15	5	439.5	0.20	112	31.01	0.519	0.968			100	98	5
	+30	6	448.4	0.21	112	31.78	0.531	1.01			100	98	5
	+45	7	457.0	0.21	111	31.75	0.532	1.02			103	99	4
	+60	8	465.325	0.26	110	35.30	0.592	1.27			104	100	5
											99		
(Net Vol. Uncorr.)				Avg.	112	32.96		1.09					

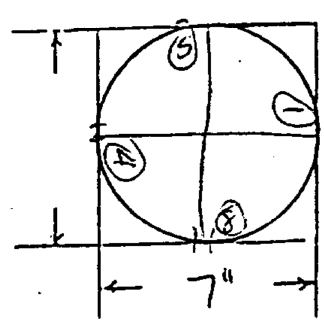
Nozzle #
Nozzle Diameter ______ mm (0.2435")
Barometric Pressure 29.92 "HgA
Static Pressure in Stack .... "HgA (+/-) 0.57 "H2O)

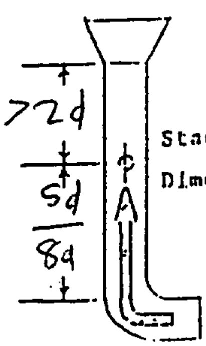
Recorded By C. W.
Pitot Factor 1.00

Calibration Data

Inclined Manometer	N0714	(Cal: N/A)
Magnehelic No.	N/A	(Cal: N/A)
Pitot Tube No.	NIST	(Cal: 2/12/98)
Potentiometer No.	N0314	(Cal: 10/21/98)
Thermocouple No.	20112	(Cal: 10/21/98)
Gas Meter No.	N0714	(Cal: 10/21/98)
Meter Corr. Factor:	1.0023	

Type Sampling Probe Glass





SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-112 Date: 10-24-98

Sampling Location: FOSS PLATING Sample Train AMB #5

TRAVERSE SOURCE TEST DATA

Pre-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.004 cfm @ 15 "Hg vac
(Pitot Tube Leak Check ________)

NO AIR

Post-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.01 cfm @ 5 "Hg vac
(Pitot Tube Leak Check ________)

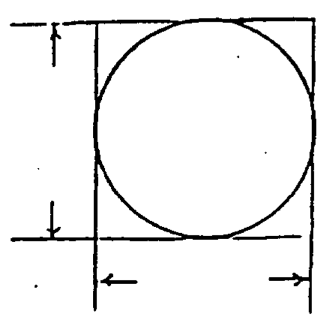
Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Velocity Head ("H_2O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Orifice ΔP ("H_2O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vacuum "Hg
12:10			764.559					2.1			79	78	5
+15			776.2					2.1			[illegible]	81	5
	+24	Time	off 783.	44									
12:03					Restart						[illegible]		
+30			788.5					2.1			[illegible]	[illegible]	5
+45			800.8					2.1			99	98	5
+60			812.0					2.1			103	97	5
+75			824.8					2.1			106	97	5
+90			836.8					2.1			107	97	5
+105			848.9					2.1			107	99	5
+120			861.0					2.1			108	100	5
+135			873.0					2.1			108	101	5
+150			885.1					2.1			108	101	5
+165			897.2					2.1			108	101	5
+180			909.3					2.1			108	101	5
+195			921.4					2.1			108	102	5
+210			933.5					2.1			108	102	5
+225			945.6					2.1			108	102	5
+240			957.7					2.1			107	101	5
+255			969.7					2.1			107	101	5
+270			981.7					2.1			107	100	5
+285			993.732					2.1			106	[illegible]	5
	1725												

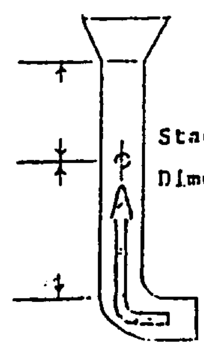
(Net Vol. Uncorr.) ______ Avg. ______

Nozzle #
Nozzle Diameter ______ mm (______ ")
Barometric Pressure 30.00 "HgA
Recorded By E. J. RAMIREZ
Pitot Factor......................______
Static Pressure in Stack......................______ "HgA (+/- ______ "H_2O)

Calibration Data

Inclined Manometer ______	(Cal: N/A)
Magnehelic No. ______	(Cal: ______)
Pitot Tube No. ______	(Cal: ______)
Potentiometer No. 60313	(Cal: 10-24-98)
Thermocouple No. ______	(Cal: ______)
Gas Meter No. 310712	(Cal: 10-21-98)
Meter Corr. Factor: 1.0049	





Type Sampling Probe GLASS

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-112 Date: 10-25-98

Sampling Location: FOSS PLATING Sample Train AmB #4

TRAVERSE SOURCE TEST DATA

Pre-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.00 cfm @ 16 "Hg vac
(Pitot Tube Leak Check ______)

Post-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.00 cfm @ 10 "Hg vac
(Pitot Tube Leak Check ______)

Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Velocity Head ("H_2O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Calculated Orifice ΔP ("H_2O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vacuum "Hg
1042			994.191					2.1			81	81	4.5
+15			005.7					2.1			87	82	4.5
+30			017.7					2.1			94	86	4.5
+45			029.7					2.1			98	89	4.5
+60			041.7					2.1			101	92	4.5
+75			053.7					2.1			102	93	4.5
+90			065.6					2.1			103	95	4.5
+105			077.7					2.1			104	96	4.5
+120			089.8					2.1			104	97	4.5
+135			101.9					2.1			105	98	4.5
+150			114.0					2.1			105	99	4.5
+165			126.1					2.1			105	99	4.5
+180			138.2					2.1			105	99	4.5
+195			150.3					2.1			106	99	4.5
+210			162.4					2.1			105	99	4.5
+225			174.5					2.1			105	99	4.5
+240			186.6					2.1			105	99	4.5
+255			198.7					2.1			105	99	4.5
+270			210.9					2.1			105	99	4.5
+285			223.0					2.1			105	99	4.5

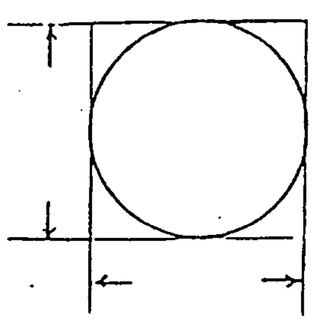
(Net Vol. Uncorr.) ______ Avg. ______

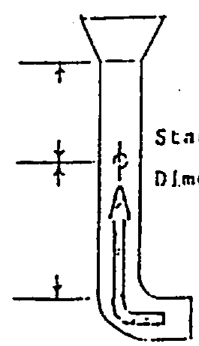
Nozzle #
Nozzle Diameter ______ mm (______ ")
Barometric Pressure 29.92 "HgA
Static Pressure in Stack .... ______ "HgA (+/- ______ "H_2O)

Recorded By E.J. RAMIREZ
Pitot Factor .... ______

Calibration Data

Inclined Manometer ______	(Cal: N/A)
Magnehelic No. ______	(Cal: ______)
Pitot Tube No. ______	(Cal: ______)
Potentiometer No. DA315	(Cal: 10-21-98)
Thermocouple No. ______	(Cal: ______)
Gas Meter No. DG715	(Cal: 10-21-98)
Meter Corr. Factor: 1.0042	





Stack Dimensions

Type Sampling Probe GLASS

TRAIN # 4

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-112 Date 10/24/98

Sampling Location TEMPORARY HOOD DUCT AT FOSS PLATING

DATA SHEET FOR VERIFICATION OF CYCLONIC FLOW

Pretest Velocity Leak Check ✓
Post Test Velocity Leak Check ✓

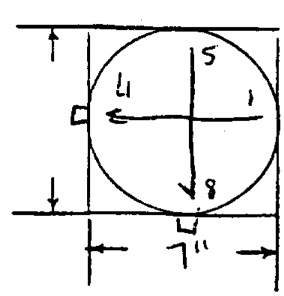
Time	Traverse Point	▲P (in. H_2O) at 0^o Reference	Null Point Rotation Angle ($\pm \alpha$)	Comments
	1		0	
	2		0	
	3		0	
	4		0	
	5		0	
	6		0	
	7		0	
	8		0	

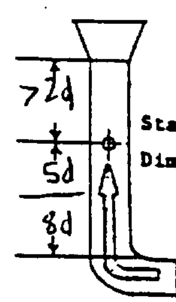
Recorded By GARIBAY

Average Absolute Values of α 0

Calibration Data

Inclined Manometer NO714 (Cal: N/A)
Magnehelic No. N/A (Cal: N/A)
Pitot Tube No. NIST (Cal: 2/12/98)





Stack Dimensi

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR THERMOCOUPLE - POTENTIOMETER CALIBRATION

Field Meter : No314 No315
STQC # : ____ S/N # : ____
Reference : ____
STQC # : ____ S/N # : ____
Temperature Source : ____

Date 10-21-98
Calibration by TN
Calibration for :
Semi annual ✓
Bi Monthly ____
Other Nickel Project

No314
Lead Wire STQC # : 50201

Temp. Sensor STQC #	A Ref. Temp.	B Ch#1	B Ch#2	ΔºF = (B-A) Ch#1	ΔºF = (B-A) Ch#2	COMMENTS
20113	212	214		2		
	212	214		2		
	212	214		2		
	412	414		2		
	412	414		2		
	412	414		2		
	716	717		+1		
		717		+1		
		717		+1		

No315
Lead Wire STQC # : 50201

Temp. Sensor STQC #	A Ref. Temp.	B Ch#1	B Ch#2	ΔºF = (B-A) Ch#1	ΔºF = (B-A) Ch#2	COMMENTS
20113	213	213		0		
	213	213		0		
	213	212		-1		
410	411	411		+1		
	411	411		+1		
	411	411		+1		
	710	711		+1		
	709	711		+1		
	709	711		+1		
				-		

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DRY GAS METER COEFFICIENT CALCULATIONS

BAROMETRIC PRESSURE (P_{bar}) 29.40 in Hg
AMBIENT TEMPERATURE 70 °F

DATE: 10-21-98
PERFORMED BY: TN

CALIBRATION PERIOD:
BIMONTHLY X
SEMIANNUAL ___
OTHER ___

Approximate Flow Rate Q (cfm)	Standard Dry Gas Meter ID# N0714 & N0715			
	Flow Rate Q_{std} (cfm)	Average Meter Temperature $\bar{T}$ (°F)	Average Meter Pressure $\bar{p}$ (in H_2O)	Corrected Flow Rate Q'_{std} (scfm)
1/4				
1/2				
3/4				
1				

1.) For non temperature compensated dry gas meters:

$$Q'_{std} = Q_{std}\left(\frac{520}{460+\bar{T}}\right)\left(\frac{P_{bar} + \frac{\bar{p}}{13.6}}{29.92}\right)$$

or Q'_{ds} ↑ Q_{ds} ↑

2.) For temperature compensated dry gas meters:

$$Q'_{ds} = Q_{ds}\left(\frac{P_{bar} + \frac{\bar{p}}{13.6}}{29.92}\right)$$

3.) $Y_{ds} = \frac{Q'_{std}}{Q'_{ds}}$

* & ** The computed values in these columns must fall within the ranges indicated in their respective column headings.

*** The computed values in this column must be greater than 0.98 and less than 1.02, i.e., $0.98 < \left(\bar{Y}_{ds} \div \bar{\bar{Y}}_{ds}\right) < 1.02$.

Overall Avg., $\bar{\bar{Y}}_{ds}$ = 1.0023 ~~x8~~ 1.0042

Approximate Flow Rate Q (cfm)	Field Dry Gas Meter ID# 7812470							
	Flow Rate Q_{ds} (cfm)	Average Meter Temperature $\bar{T}$ (°F)	Average Meter Pressure $\bar{p}$ (in H_2O)	Corrected Flow Rate Q'_{ds} (scfm)	* Coefficient Y_{ds} < (1+/− 0.05)	** (Y_{ds} max − Y_{ds} min) <=0.010	Average Coefficient $\bar{Y}_{ds}$	*** $\frac{\bar{Y}_{ds}}{\bar{\bar{Y}}_{ds}}$
1/4								
1/2								
3/4								
1								

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR DRY GAS METER CALIBRATION

STANDARD IDENTIFICATION (S/N) N70714
DRY GAS METER IDENTIFICATION (S/N) 78 12470
DRY GAS METER IDENTIFICATION (STQC) N0714
BAROMETRIC PRESSURE (P_{bar}) 29.40
AMBIENT TEMPERATURE 70

DATE: 6-21-98
CALIB. BY: TN
CALIBRATION FOR:
SEMI ANNUAL
MONTHLY BM1
OTHER

N0714

Approx. CFM Project	Total CF		Crit. Orif. ΔP in H_2O	Secondary Standard Dry Gas Meter: Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM	(Dry Gas Meter): Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM
1/2		Start				187.6	0				4.4 / 2.0	612.0	0		
		End				203.9					4.4 / 2.0	628.3			
		Avg. or Total		70	4.3		21.31.30			71			21.32.61		
		Start				~~209.0~~						628.4	0		
		End				211.7						636.1			
		Avg. or Total		70	4.3		10.09.29			71			10.09.30		
3		Start				211.8						636.3	0		
		End				252.3						649.6			
		Avg. or Total		70	4.3		17.48.79			71			17.35.55		
3/4		Start				306.3					2.3 / .9	730.2	0		
		End				312.1					2.3 / .9	736.1			
		Avg. or Total		70	2.3		10.50.61			71			11.04.71		
		Start				312.2						736.2	0		
		End				317.3	9.31.06					741.2			
		Avg. or Total		70	2.7					71			9.24.33		
		Start				317.4						741.3	0		

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR DRY GAS METER CALIBRATION

STANDARD IDENTIFICATION (S/N) 7892470
DRY GAS METER IDENTIFICATION (S/N) ______
DRY GAS METER IDENTIFICATION (STQC) N0715
BAROMETRIC PRESSURE (P_{bar}) 29.40
AMBIENT TEMPERATURE 70

DATE: 10-21-98
CALIB. BY: TN
CALIBRATION FOR:
SEMI ANNUAL ______
MONTHLY BM1
OTHER ______

Approx. CFM Project	Total CF		Crit. Orif. ΔP in H_2O	Secondary Standard Dry Gas Meter: Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM	(Dry Gas Meter): Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM
1/2		Start				468.2	0				1.5 / 1.3	612.4	0		
		End				457.8					1.5 / 1.3	622.0			
		Avg. or Total		70	1.8		17.57.60			~~N~~70			18.21.71		
		Start				45~~7~~9.9	0					622.1	0		
		End				471.0						645			
		Avg. or Total		70			24.30.20			70		634.8	24.17.40		
		Start				471.1	0					634.9	0		
		End				476.7						640.4			
		Avg. or Total		70			10.28.65			70			10.30.82		
3/4		Start				512.1	0				2.9 / 2.5	675.0	0		
		End				531.8					2.9 / 2.5	694.4			
		Avg. or Total		70	3.2		24.54.60			70			25.30.82		
		Start				531.9	0					694.6	0		
		End				543.0						705.4			
		Avg. or Total		70			14.02.45			70			~~25.07.9~~	13.58.00	
		Start				543.1	0					705.5	0		

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DRY GAS METER COEFFICIENT CALCULATIONS

CALIBRATION PERIOD:

BAROMETRIC PRESSURE (P_{bar}) 29.16 in Hg

AMBIENT TEMPERATURE 70 °F

DATE: 7-31-98

PERFORMED BY: TN

BIMONTHLY
SEMIANNUAL X
OTHER

Approximate Flow Rate Q (cfm)	Standard Dry Gas Meter ID# 7812470			
	Flow Rate Q_{std} (cfm)	Average Meter Temperature $\bar{T}$ (°F)	Average Meter Pressure $\bar{p}$ (in H_2O)	Corrected Flow Rate Q'_{std} (scfm)
1/4				
1/2				
3/4				
1				

1.) For non temperature compensated dry gas meters:

$$Q'_{std} = Q_{std}\left(\frac{520}{460+\bar{T}}\right)\left(\frac{P_{bar} + \frac{\bar{p}}{13.6}}{29.92}\right)$$

or Q'_{ds} ↑ Q_{ds} ↑

2.) For temperature compensated dry gas meters:

$$Q'_{ds} = Q_{ds}\left(\frac{P_{bar} + \frac{\bar{p}}{13.6}}{29.92}\right)$$

3.) $Y_{ds} = \frac{Q'_{std}}{Q'_{ds}}$

* & ** The computed values in these columns must fall within the ranges indicated in their respective column headings.

*** The computed values in this column must be greater than 0.98 and less than 1.02, i.e., $0.98 < \left(\bar{Y}_{ds} \div \bar{\bar{Y}}_{ds}\right) < 1.02$

Overall Avg., $\bar{\bar{Y}}_{ds}$ = 1.0023

Approximate Flow Rate Q (cfm)	Field Dry Gas Meter ID# NO714							
	Flow Rate Q_{ds} (cfm)	Average Meter Temperature $\bar{T}$ (°F)	Average Meter Pressure $\bar{p}$ (in H_2O)	Corrected Flow Rate Q'_{ds} (scfm)	* Coefficient Y_{ds} < (1+/− 0.05)	** (Y_{ds} max − Y_{ds} min) <=0.010	Average Coefficient $\bar{Y}_{ds}$	*** $\bar{Y}_{ds} / \bar{\bar{Y}}_{ds}$
1/4					.9844			
					1.0011			
					1.0588			
1/2					.9913			
					1.0032			
					1.0032			
3/4					.9991			
					.9975			
					1.0032			
1					.9942			
					.9944			
					.9970			

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR DRY GAS METER CALIBRATION

STANDARD IDENTIFICATION (S/N) ~~N~~ 714 782470

DRY GAS METER IDENTIFICATION (S/N) ____

DRY GAS METER IDENTIFICATION (STQC) N0714

BAROMETRIC PRESSURE (P_{bar}) 29.16

AMBIENT TEMPERATURE 70

DATE: 7-31-98

CALIB. BY: TN

CALIBRATION FOR:

SEMI ANNUAL X

MONTHLY ____

OTHER ____

Approx. CFM Project	Total CF		Crit. Orif. ΔP in H_2O	Secondary Standard Dry Gas Meter						(Dry Gas Meter)					
				Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM	Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM
1/4		Start				439.3	0			.95 / .25	0	503.6	0		
		End				445.2				.95 / .25		509.6			
		Avg. or Total		70	1.05		21.23.62				70		21.47.22		
		Start				445.3	0					509.8	0		
		End				450.3						514.8	18.30.01		
		Avg. or Total		70	1.05		18.08.13				70				
		Start				450.4	0					515.0	0		
		End				455.9						520.2			
		Avg. or Total		70	1.05		19.57.13				70		18.54.02		
3/2		Start				475.8	0				3.2 / 1.0	540.2	0		
		End				484.1					3.2 / 1.0	548.6			
		Avg. or Total		70	3.4		14.57.60				70		15.02.05		
		Start				484.2	0					548.7	0		
		End				490.7						555.2			
		Avg. or Total		70	3.4		11.40.28				70		11.38.14		
		Start				490.8	0					555.3	0		
		[illegible]				[illegible]						[illegible]			

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR DRY GAS METER CALIBRATION

STANDARD IDENTIFICATION (S/N) 7812470
DRY GAS METER IDENTIFICATION (S/N) ______
DRY GAS METER IDENTIFICATION (STQC) N0714
BAROMETRIC PRESSURE (P_{bar}) 29.16
AMBIENT TEMPERATURE 70

DATE: 7-31-98
CALIB. BY: TN
CALIBRATION FOR:
SEMI ANNUAL X
MONTHLY ______
OTHER ______

Approx. CFM Project	Total CF		Crit. Orif. ΔP in H_2O	Secondary Standard Dry Gas Meter: Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM	(Dry Gas Meter): Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM
3/4		Start				508.4	0				6.1 / 2.2	572.9	0		
		End				518.4					6.1 / 2.2	583.1			
		Avg. or Total		70	6.2		12.36.59			70			12.47.14		
		Start				518.6	0					583.3	0		
		End				527.2						591.9			
		Avg. or Total		70	6.2		10.50.85			70			10.45.96		
		Start				527.3	0					592.0	0		
		End				540.6	16:40.57					602.0			
		Avg. or Total		70	6.2		~~12.01.30~~			70			12.30.94		
1		Start				540.8	0				10.3 / 10.0	605.6	0		
		End				549.7					10.3 / 7.8	614.8			
		Avg. or Total		70	10.5		8.39.80			70			8.49.68		
		Start				549.9	0					615.0	0		
		End				555.1						620.3			
		Avg. or Total		70	10.5		5.04.17			70			5.05.68		
		Start				555.3	0					620.5	0		

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DRY GAS METER COEFFICIENT CALCULATIONS

BAROMETRIC PRESSURE (P_{bar}) 29.12 in Hg

AMBIENT TEMPERATURE 70 °F

DATE: 7/30/98

PERFORMED BY: JN

CALIBRATION PERIOD:

BIMONTHLY ___
SEMIANNUAL X
OTHER ___

Approximate Flow Rate Q (cfm)	Standard Dry Gas Meter ID#			
	Flow Rate Q_{std} (cfm)	Average Meter Temperature $\bar{T}$ (°F)	Average Meter Pressure $\bar{p}$ (in H_2O)	Corrected Flow Rate Q'_{std} (scfm)
1/4				
1/2				
3/4				
1				

1.) For non temperature compensated dry gas meters:

$$Q'_{std} = Q_{std}\left(\frac{520}{460+\bar{T}}\right)\left(\frac{P_{bar} + \frac{\bar{p}}{13.6}}{29.92}\right)$$

or Q'_{ds} ... Q_{ds}

2.) For temperature compensated dry gas meters:

$$Q'_{ds} = Q_{ds}\left(\frac{P_{bar} + \frac{\bar{p}}{13.6}}{29.92}\right)$$

3.) $Y_{ds} = \dfrac{Q'_{std}}{Q'_{ds}}$

* & ** The computed values in these columns must fall within the ranges indicated in their respective column headings.

*** The computed values in this column must be greater than 0.98 and less than 1.02, i.e., $0.98 < \left(\bar{Y}_{ds} \div \bar{\bar{Y}}_{ds}\right) < 1.02$

Overall Avg., $\bar{\bar{Y}}_{ds}$ = 1.0042

Approximate Flow Rate Q (cfm)	Field Dry Gas Meter ID# N0715							
	Flow Rate Q_{ds} (cfm)	Average Meter Temperature $\bar{T}$ (°F)	Average Meter Pressure $\bar{p}$ (in H_2O)	Corrected Flow Rate Q'_{ds} (scfm)	* Coefficient Y_{ds} < (1+/- 0.05)	** (Y_{ds} max − Y_{ds} min) <=0.010	Average Coefficient $\bar{Y}_{ds}$	*** $\bar{Y}_{ds} / \bar{\bar{Y}}_{ds}$
1/4					1.0077			
					1.0039			
					1.0033			
1/2					1.0097			
					1.0076			
					1.0068			
3/4					1.0043			
					1.0025			
					1.0030			
1					0.9992			
					0.9994			
					0.9969			

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR DRY GAS METER CALIBRATION

STANDARD IDENTIFICATION (S/N) 7812470

DRY GAS METER IDENTIFICATION (S/N) ____

DRY GAS METER IDENTIFICATION (STQC) NO715

BAROMETRIC PRESSURE (P_{bar}) 29.12

AMBIENT TEMPERATURE 70

DATE: 7-30-98

CALIB. BY: TON

CALIBRATION FOR:

SEMI ANNUAL X

MONTHLY ____

OTHER ____

Approx. CFM Project	Total CF		Crit. Orif. ΔP in H_2O	Secondary Standard Dry Gas Meter						(Dry Gas Meter)					
				Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM	Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM
3/4		Start				361.6	0				6.0 2.0	871.3	0		
		End				374.5					6.0 2.0	884.3			
		Avg. or Total		70	6.2		16.38.68			70			16.45.23		
		Start				374.6	0					884.4	0		
		End				391.8						901.6			
		Avg. or Total		70	6.2		22.13.43			70			22.09.49		
		Start				391.9	0					901.7	0		
		End				402.1						911.9			
		Avg. or Total		70	6.2		13.11.12			70			13.09.2[illegible]		
1		Start				410.7	0				9.8 3.5	920.6	0		
		End				422.8					9.8 3.5	932.9			
		Avg. or Total		70	10		11.57.09			70			12.02.40		
		Start				423.0	0					933.1	0		
		End				428.0						938.2			
		Avg. or Total		70	10		4.56.28			70			4.59.54		
		Start				428.2	0					938.4	0		
		End				433.4						943.5			

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR DRY GAS METER CALIBRATION

STANDARD IDENTIFICATION (S/N) 7812470
DRY GAS METER IDENTIFICATION (S/N) ______
DRY GAS METER IDENTIFICATION (STQC) N0715
BAROMETRIC PRESSURE (P_{bar}) 29.12
AMBIENT TEMPERATURE 70

DATE: 7/30/98
CALIB. BY: ______
CALIBRATION FOR:
SEMI ANNUAL X
MONTHLY ______
OTHER ______

Approx. CFM Project	Total CF		Crit. Orif. ΔP in H_2O	Secondary Standard Dry Gas Meter: Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM	(Dry Gas Meter): Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM
1/4		Start				289.6	0				1.0 .3	799.4	0		
		End				294.9					1.0 .3	804.8			
		Avg. or Total		70	1.2		17.3624			70			18.0296		
		Start				295.0	0					804.9	0		
		End				300.7						810.6			
		Avg. or Total		70	1.2		18.5920			70			19.0217		
		Start				300.8	0					810.7	0		
		End				307.9						817.6			
		Avg. or Total		70	1.2		23.3451			70			23.04.21		
1/2		Start				318.3	0				3.1 .9	828.0	0		
		End				325.1					3.1 .9	834.9			
		Avg. or Total		70	3.3		12.4170			70			12.5786		
		Start				325.2	0					835.0	0		
		End				331.8						841.5			
		Avg. or Total		70	3.3		12.1963			70			12.1159		
		Start				331.9	0					841.6	0		

U.S. DEPARTMENT OF COMMERCE

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
Gaithersburg, MD 20899

REPORT OF SPECIAL TEST

OF
AIR SPEED INSTRUMENTATION

March 11, 1998

Two Pitot-Static Tubes

submitted by

South Coast Air Quality Management District
Applied Science & Technology
21865 E. Copley Drive
Diamond Bar, CA 91765 4182

The calibration of the Pitot static tubes were performed in the 1 m (three-foot) by 1 m (three-foot) NIST Low Velocity Airflow Facility. The instrument under test was supported near the center of the tunnel in a manner that presented negligible interference to the flow. The air speed was measured by the NIST laboratory standard laser velocimeter on the centerline of the tunnel, upstream of the Pitot-static tubes. The air temperature, humidity, and atmospheric pressure were measured inside the tunnel.

The calibration of the Pitot-static tube consists of determining the calibration factor, K, defined as the square root of the ratio of the air speed indicated by the instrument under test to the air speed indicated by the NIST laboratory standard velocimeter. K may be a function of the Reynolds number, Re, which is expressed as

$$Re = Vd/\nu$$

where V is the air speed, d is the diameter of the Pitot-static tube, and ν is the kinematic viscosity. Two calibration cycles were done, separated by a shutdown. Each speed in each cycle is measured five times.

Tables 1 and 2 and Figure 1 show the expanded uncertainty values for the NIST air speed calibration facilities.[1] The data listed in the remaining tables are calculated from the means of the 10 measurements at each speed. Listed are the air speed measured by the NIST standard, K, Re, and the expanded uncertainty of the measurements for the instrument under test.

The expanded uncertainty of the measured values for the instrument under test, U, is given by[2]

$$U = k\sqrt{u_i^2}$$

where k is the coverage factor, taken to be 2, and the u_i are the contributions to the uncertainty from various sources. For this calibration, there are two sources of uncertainty: u_1 is the standard deviation of the ten measurements at each speed, and u_2 is one half the uncertainty at a given speed shown in Tables 1 and 2 and in Figure 1, which was obtained through the characterization of the NIST standards.

For the Director,
National Institute of Standards and Technology

G.E. Mattingly

Dr. George E. Mattingly
Leader, Fluid Flow Group
Process Measurements Division
Chemical Science and Technology Laboratory

[1] N. E. Mease, W. G. Cleveland, Jr., G. E. Mattingly, and J. M. Hall, "Airspeed Calibrations at the National Institute of Standards and Technology," Proceedings of the 1992 Measurement Science Conference, Anaheim, CA, 1992.

[2] B.N. Taylor and C.E. Kuyatt, "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results," NIST Technical Note 1297, National Institute of Standards and Technology, January 1993.

Expanded Uncertainties for NIST Air Speed Facilities

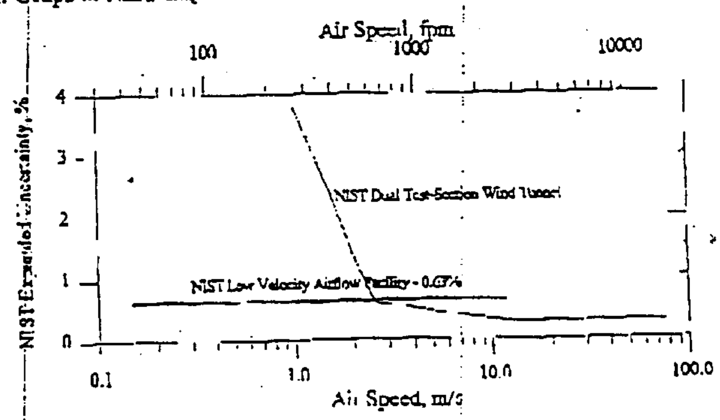
Table 1. Expanded Uncertainty of the NIST Low Velocity Airflow Facility

Air Speed, m/s	Uncertainty, (%)	Air Speed, fpm
up to 10	0.6	up to 2200

Table 2. Expanded Uncertainty of the NIST Dual Test-Section Wind Tunnels

Air Speed, m/s	Uncertainty, %	Air Speed, fpm
1	3.8	200
2	1.3	400
3	0.6	600
5	0.45	1000
10	0.31	2000
15 - 75	0.28	3000 - 15000

Figure 1. Graph of NIST Expanded Uncertainties - all facilities



SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
21865 Copley Dr., Diamond Bar, CA 91765-4182

MONITORING AND ANALYSIS
LABORATORY ANALYSIS REPORT

TO Mike Garibay, Engineer II
Source Testing & Engineering
Monitoring & Analysis

SAMPLE Seven Nickel Trains
One Reagent Blank

SOURCE Foss Plating
Nickel Plating Tanks
8140 Secura Way
Santa Fe Springs, CA

LABORATORY NO 93008-02

REFERENCE NO JSV-25-50

SOURCE TEST NO 98-112

PREPARATION NO 92938-12

DATE RECEIVED 10/27/98

ANALYTICAL WORK PERFORMED, METHOD OF ANALYSIS, AND RESULTS
Nickel by CARB Method 433

Equip Number(s)	10	2	6	3	7	4	5
Sample point	field blank	no air	no air	air	air	amb	amb
Moisture gain (loss), g	(0.1)	79.4	107.6	109.0	93.1	71.4	52.5
Silica gel expended, percent	<10	60	65	50	60	85	60
Notes on train condition	(1)	(2)		(3)	(3)		
Total nickel, ug	16.5	2950	3600	1170	1350	306	32.5

Comments and deviations:
(1) New filter
(2) Bath solution on probe exterior
(3) Solvent-like odor, possibly alcohol.

M&AD RECEIVED
DEC 30 1998
M&E BRANCH

Samples were reported with reagent blank subtracted. Reagent blank was 2.5 ug total.
Samples were analyzed by West Coast Analytical Services (WCAS) by ICP/MS. (see attached report WCAS Job No 39762)

Date Approved: 12/29/98

Approved By: [signature]
Rudy Eden, Senior Manager
Laboratory Services

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WEST COAST ANALYTICAL SERVICE, INC.
Analytical Chemists

November 10, 1998

SOUTH COAST AIR QUALITY MANAGEMENT
Laboratory Services Div.
21865 Copley Drive
Diamond Bar, CA 91765-4182

Attn: Joan Niertit

Job No: 39762 S

LABORATORY REPORT

Samples Received: Eight (8) Liquids
Date Received: 11/04/98
Purchase Order No: 99107

The samples were analyzed as follows:

Analysis	Page
Nickel by ICPMS	2

Charles Jacks, Ph.D.
Senior Staff Chemist

D.J. Northington, Ph.D.
Quality Assurance Officer

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WEST COAST ANALYTICAL SERVICE, INC.

SOUTH COAST AIR QUALITY MANAGEMENT
Attn: Joan Niertit

Job No: 39762
November 10, 1998

LABORATORY REPORT

Nickel
Quantitative Analysis Report
Inductively Coupled Plasma-Mass Spectrometry

Parts Per Million (mg/L)

Sample ID	Nickel
Reag Bl	0.025
Train #2 No Air	29.5
Train #3 Air	11.7
Train #4 amb	3.08
Train #5 amb	0.35
Train #6 No Air	36
Train #7 Air	13.5
Train #10 blk	0.19
Detection Limit:	0.002

Date Analyzed: 11-9-98

Quality Control Summary

Sample: Standard Reference Material USGS T111

	Certified Value ug/L	Found ug/L	% Acceptable Error	% Error
Nickel	15.5	17.8	20	14.8%

Date Analyzed: 11-9-98

Abbreviations Summary

General Reporting Abbreviations:

B	Blank - Indicates that the compound was found in both the sample and the blank. The sample value is reported without blank subtraction. If the sample value is less than 10X the blank value times the sample dilution factor, the compound may be present as a laboratory contaminant.
D	Indicates that the sample was diluted, and consequently the surrogates were too dilute to accurately measure.
DL	Detection Limit - Is the minimum value which we believe can be detected in the sample with a high degree of confidence, taking into account dilution factors and interferences. The reported detection limits are equal to or greater than Method Detection Limits (MDL) to allow for day to day and instrument to instrument variations in sensitivity.
J	Indicates that the value is an estimate.
ND	Not Detected - Indicates that the compound was not found in the sample at or above the detection limit.
ppm ppb	Parts per million (billion) in liquids is usually equivalent to mg/l (ug/l), or in solids to mg/kg (ug/kg). In the gas phase it is equivalent to ul/l (ul/m^3).
TR	Trace - Indicates that the compound was observed at a value less than our normal reported Detection Limit (DL), but we feel its presence may be important to you. These values are subject to large errors and low degrees of confidence.

kg	kilogram	mg	milligram	l	liter	m	meter
g	gram	ug	microgram	ul	microliter		

QC Abbreviations:

Control & Warning Limits	QC Limits are determined from historical data. The test value must be within the Control Limits for the test to be considered valid. Based on historical data, the confidence intervals are 95% for warning limits and 99% for control limits.
% Error	Percent Error - This is a measure of accuracy based on the analysis of a Laboratory Control Standard (LCS). An LCS is a reference sample of known value such as an NIST Standard Reference Material (SRM). The % Error is expressed in percent as the difference between the known value and the experimental value, divided by the known value. The LCS may simply be a solution based standard which confirms calibration (ICV or CCV - initial or continuing calibration verification), or it may be a reference sample taken through preparation and analysis.

WESTERN ANALYTICAL LABORATORIES, INC.

13744 MONTE VISTA AVENUE · CHINO, CALIFORNIA 91710 · (909) 627-3628 · FAX (909) 627-0491

CUSTOMER SOUTH COAST AQMD

WAL NO. 8110291

DATE RECEIVED 11/12/98

ATTENTION JOHN MCLAUGHLIN

DATE OF REPORT 11/17/98

SAMPLE IDENTIFICATION: NICKEL SULFATE PLATING SOLUTION

FOSS PLATING CO

TANK NO. ______ GALLONS ______ SAMPLED 11/12/98

ANALYSIS	STANDARD	RESULTS
		63/GAL
NICKEL		5.85 43.8 g/l
NICKEL SULFATE		15.?? 140 g/l
NICKEL CHLORIDE		6.77 50.4 g/l
BORIC ACID		4.03 30.2 g/l
pH		4.75
SURFACE TENSION		47.0 dyne/cm

1002 CONT

Appendix I

SCAQMD Source Test Results
California Technical Plating

South Coast
Air Quality Management District
21865 E. Copley Drive, Diamond Bar, CA 91765-4182
(909) 396-2000 · http://www.aqmd.gov

SOURCE TEST REPORT

98-109, 98-110, and 98-111

Conducted at

California Technical Plating Company
11533 Bradley Avenue
San Fernando, CA 91340

NICKEL EMISSIONS FROM A NICKEL ELECTROPLATING TANK WITH AND WITHOUT AIR AGITATION

TESTED:	September 3 - 11, 1998
ISSUED:	November 25, 1998
REPORTED BY:	Michael Garibay Air Quality Engineer II

REVIEWED BY:

Edward J. Ramirez
Senior Air Quality Engineer

MONITORING AND ENGINEERING BRANCH

MONITORING AND ANALYSIS DIVISION

BACKGROUND

a. Firm. .... California Technical Plating Company

b. Test Location .... 11533 Bradley St., San Fernando, CA 91340

c. Unit Tested.. Nickel Electroplating Tank

d. Test Requested by .... Jill Whynot, Stationary Source Compliance, (SSC) (909)396-3104

e. Reason for Test Request...................... Develop Emission Factors for Rule 1401

f. Dates of Test.. September 3, 4, & 11,1998

g. Source Test Performed by .... E. Ramirez
M. Garibay, G. Kasai, C. Willoughby

h. Test Arrangements Made Through ...... Dave Anzures, Sr. (818) 365-8205
Sam Patel, (818) 365-8205

i. Source Test Observed by...................... Dave Anzures, Jr. (818) 365-8205
Sam Patel, (818) 365-8205
Dennis Becvar, Pacific Environmental Services, Inc. (PES) (626) 856-1400

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RESULTS

Nickel Emissions from a Semi-Bright Nickel Electroplating Tank - with Air Agitation

Run #	lb/(hr-scfm$_{air}$)	lb/(hr-ft$^2_{tank}$)	lb/(hr-ft$^2_{parts}$)	mg/dscm	mg/(A-hr)
1	6.33×10^{-6}	5.51×10^{-6}	1.42×10^{-5}	0.059	0.264
2	7.66×10^{-6}	6.67×10^{-6}	1.72×10^{-5}	0.067	0.319
3	3.89×10^{-6}	3.46×10^{-6}	8.92×10^{-6}	0.035	0.171
Average	5.96×10^{-6}	5.21×10^{-6}	1.34×10^{-5}	0.054	0.251
Ambient	-	-	-	1.57×10^{-3}	-

Nickel Emissions from a Semi-Bright Nickel Electroplating Tank - No Air Agitation

Run #	lb/hr	lb/(hr-ft$^2_{tank}$)	lb/(hr-ft$^2_{parts}$)	mg/dscm	mg/(A-hr)
1	2.29×10^{-6}	1.53×10^{-7}	3.93×10^{-7}	1.57×10^{-3}	0.008
2	4.25×10^{-5}	2.83×10^{-6}	7.30×10^{-6}	2.97×10^{-2}	0.143
3	3.56×10^{-5}	2.37×10^{-6}	6.12×10^{-6}	2.45×10^{-2}	0.121
Average	2.68×10^{-5}	1.79×10^{-6}	4.60×10^{-6}	1.86×10^{-2}	0.090
Ambient	-	-	-	8.38×10^{-4}	-

INTRODUCTION

The South Coast Air Quality Management District (SCAQMD), is attempting to gather information on nickel, hydrogen chloride, and sodium hydroxide emissions from plating and metal treating processing from nickel plating facilities. The testing was requested to provide improved data on emissions from these operations and address unresolved issues under SCAQMD Rule 1401.

Previous testing conducted by the Metal Finishing Association of Southern California (MFASC) and the California Air Resources Board (CARB) consisted of triplicate tests for nickel from nickel electroplating. The current testing is intended to resolve issues raised during the review of the MFASC test regarding high levels of background nickel and potential fugitive losses. The testing is also intended to evaluate the representativeness of existing emission factors. The scope of the current testing effort has been expanded to measure nickel emissions from electroless nickel plating operations, hydrogen chloride from metal acid treating tanks and sodium hydroxide from metal treating tanks at nickel plating facilities. This test report, which is part of the series of tests intended to collect this information, reports emissions from a nickel electroplating tank with and without air agitation. The complete testing series in the project consist of SCAQMD Source Tests: 98-105, 98-106, 98-107, 98-108, 98-109, 98-110, and 98-111.

The test plan was developed via a cooperative effort with the SCAQMD and MFASC. This test report incorporates and addresses comments from representatives from both the SCAQMD and MFASC during weekly meetings from the projects beginning to end. The testing was conducted at a volunteer MFASC member facility with excellent building ventilation so as to avoid background interference. The sampling was conducted by SCAQMD Methods and Testing staff. The analysis was conducted by the SCAQMD laboratory and SCAQMD contractor.

The testing consisted of two sets of triplicate two hour sampling runs with one set run under the air agitation operating condition and the second set run without the air agitation. The results are reported in units of milligrams nickel per plating amperage - plating elapsed time (mg/A-hr), as well as other units. The results of the testing are intended to be used as emissions factors in health risk exposure assessments. As with other types of plating processes, the emissions are reported on a per ampere-hour basis so that ampere hour data commonly collected in the industry can be used to track the total mass emissions.

PROCESS DESCRIPTION

Background

In the plating industry, nickel plating is employed as a decorative and/or protective layer over a variety of metal pieces. The nickel plating can be used as a final finish or covered with a thin plating of chromium as with decorative chrome applications. The nickel plating can be conducted using electrodes and electromotive force or using an electroless process. Emissions are produced as small droplets of the solution in aerosol form due to bubbling in the tanks caused by electrolysis or other processes such as air agitation commonly employed to enhance the plating process.

In the electrolytic plating process, the parts are immersed in an acidic solution with ionic nickel where a current is applied so that solid nickel is plated onto the parts. An immersion heater can be employed in the plating tanks to maintain a desired plating bath temperature. This type of plating employs a surface tension reducing agent to reduce the surface tension to approximately 35 dynes/cm for purposes of minimizing pitting in the plating process. The solutions within the tanks are agitated by pump recirculation or by bubbling with air. Either a bright or semi-bright plated finish can be accomplished depending on the additives in the plating solution. The tanks are equipped with rectifiers to produce a low voltage high amperage DC current. According to the Lawrence J. Durney, *Electroplating Engineering Handbook*, the metal parts are plated with a current density of 20 - 50 amperes per square foot of plating surface area. The majority of the existing nickel electroplating tanks are not vented by a dedicated ventilation system. The buildings that house these processes, typically employ some type of ventilation system which may be forced draft, natural draft, or cross draft in nature.

For the electroless nickel plating, the plating is driven by difference in electropotential. The solution differs from the electroplating solution to enhance this process. For electroless applications, since the solutions contain odiferous compounds such as ammonia, the plating tanks typically include ventilation systems at a close proximity above the plating tanks to draw emissions from the plating tanks out of the work space.

The nickel platers also employ both hydrochloric acid and sodium hydroxide metal treating processes. The hydrochloric acid process is an etching process in which bubbling occurs due to gasses produced as the metal is etched. The sodium hydroxide process can be employed by spraying, electrocleaning, etching (for aluminum), or soak cleaning with a detergent. Of the sodium hydroxide processes, the soak cleaning is expected to produce the least amount of emissions, while the spraying is expected to produce the highest.

Nickel Plating Operation During Testing

During testing, the nickel electroplating tank was operated during active plating for the entire test period excluding a brief period where the parts were removed to simulate drag-out effects. Dummy parts were used as a plating substrate as shown in Figure 1. The host facility requested that the rectifier not be operated above 150 amperes due to potential over-heating of the rectifier. The dummy parts were sized so that a plating current density of approximately 20 amperes per square foot was obtained at below 150 amperes total current. This current density was chosen so as to be as consistent as possible with the past MFASC testing current density of 17 amperes per square foot while also keeping in the 20-50 A/ft^2 range of normal nickel plating as specified in the *Electroplating Engineering Handbook*. Since the parts were not entirely submerged in the plating solution the actual current density applied was calculated using the resulting plated surface area. As with the past MFASC testing, the dummy parts were lifted out and replaced back into the solution six times during each sampling run, to simulate drag-out and disturbance of the solution surface during normal operation. The tank was equipped with a circulation pump and filter as well as a parts agitator which moves the parts in a linear cyclical manner. The parts agitator was operated during the non-air agitated tests only to maintain normal operation under both air and non-air agitated conditions. Photographs of the host plating tank and the surface of the solution both with and without air agitation are shown in Figures 2, 3, and 4. The following are the specifications of the nickel plating tank and the lists of operating conditions that were monitored during each of the test runs:

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Tank Dimensions	Rectifier Rated Capacity	Type of Plating
36"W x 60"L x 48"H	500 amperes	Semi-Bright Nickel

Operating Conditions Recorded During Testing - Air Agitation Run #1

Freeboard Height	4	inches
Plating Solution Temperature	121	°F
Plating Solution Nickel Content	10.3	oz/gal
Plating Solution Boric Acid Content	5.0	oz/gal
Plating Solution pH	3.5	pH
Plating Solution Surface Tension	37.9	dynes/cm
Plating Solution Specific Gravity	1.27	
Plating Voltage	6.5	volts
Average Amperage Applied	142	amperes
Calculated Ampere-hour Usage	284	A-hr
Calculated Current Density	24.4	A/ft^2
Number of Dummy Parts	4	plates
Total Surface Area of Plated Parts	5.82	ft^2
Plating Period within Test Run	120	min / test run
Duration of Test Runs	120	min /test run
Capture Efficiency of Ventilation System	100	%
Ventilation Rate	422	acfm
Air Agitation Rate	13.0	scfm
Air Agitation Rate per unit solution surface area	0.87	$scfm/ft^2$
Part Agitation Rate	0	in/min
Solution Circulation Rate	5 - 7	gpm (estimated)

<u>Operating Conditions Recorded During Testing - Air Agitation Run #2</u>

Freeboard Height	4	inches
Plating Solution Temperature	119	^{o}F
Plating Solution Nickel Content	10.3	oz/gal
Plating Solution Boric Acid Content	5.0	oz/gal
Plating Solution pH	3.5	pH
Plating Solution Surface Tension	37.9	dynes/cm
Plating Solution Specific Gravity	1.27	
Plating Voltage	6.5	volts
Average Amperage Applied	142	amperes
Calculated Ampere-hour Usage	284	A-hr
Calculated Current Density	24.4	A/ft^2
Number of Dummy Parts	4	plates
Total Surface Area of Plated Parts	5.82	ft^2
Plating Period within Test Run	120	min / test run
Duration of Test Runs	120	min /test run
Capture Efficiency of Ventilation System	100	%
Ventilation Rate	452	acfm
Air Agitation Rate	13.0	scfm
Air Agitation Rate per unit solution surface area	0.87	scfm/ft^2
Part Agitation Rate	0	in/min
Solution Circulation Rate	5 - 7	gpm (estimated)

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Operating Conditions Recorded During Testing - Air Agitation Run #3

Freeboard Height	4	inches
Plating Solution Temperature	120	°F
Plating Solution Nickel Content	10.3	oz/gal
Plating Solution Boric Acid Content	5.0	oz/gal
Plating Solution pH	3.5	pH
Plating Solution Surface Tension	37.9	dynes/cm
Plating Solution Specific Gravity	1.27	
Plating Voltage	6.0	volts
Average Amperage Applied	138	amperes
Calculated Ampere-hour Usage	276	A-hr
Calculated Current Density	23.7	A/ft^2
Number of Dummy Parts	4	plates
Total Surface Area of Plated Parts	5.82	ft^2
Plating Period within Test Run	120	min / test run
Duration of Test Runs	120	min /test run
Capture Efficiency of Ventilation System	100	%
Ventilation Rate	433	acfm
Air Agitation Rate	13.4	scfm
Air Agitation Rate per unit solution surface area	0.89	scfm/ft^2
Part Agitation Rate	0	in/min
Solution Circulation Rate	5 - 7	gpm (estimated)

Operating Conditions Recorded During Testing - No Air Agitation Run #1

Freeboard Height	4	inches
Plating Solution Temperature	124	°F
Plating Solution Nickel Content	10.3	oz/gal
Plating Solution Boric Acid Content	5.0	oz/gal
Plating Solution pH	3.5	pH
Plating Solution Surface Tension	37.9	dynes/cm
Plating Solution Specific Gravity	1.27	
Plating Voltage	6.0	volts
Average Amperage Applied	138	amperes
Calculated Ampere-hour Usage	276	A-hr
Calculated Current Density	23.7	A/ft^2
Number of Dummy Parts	4	plates
Total Surface Area of Plated Parts	5.82	ft^2
Plating Period within Test Run	120	min / test run
Duration of Test Runs	120	min /test run
Capture Efficiency of Ventilation System	100	%
Ventilation Rate	431	acfm
Air Agitation Rate	0	scfm
Air Agitation Rate per unit solution surface area	0	$scfm/ft^2$
Part Agitation Rate	77	in/min
Solution Circulation Rate	5 - 7	gpm (estimated)

Operating Conditions Recorded During Testing - No Air Agitation Run #2

Freeboard Height	4	inches
Plating Solution Temperature	123	°F
Plating Solution Nickel Content	10.3	oz/gal
Plating Solution Boric Acid Content	5.0	oz/gal
Plating Solution pH	3.5	pH
Plating Solution Surface Tension	37.9	dynes/cm
Plating Solution Specific Gravity	1.27	
Plating Voltage	6.6	volts
Average Amperage Applied	135	amperes
Calculated Ampere-hour Usage	270	A-hr
Calculated Current Density	23.2	A/ft^2
Number of Dummy Parts	4	plates
Total Surface Area of Plated Parts	5.82	ft^2
Plating Period within Test Run	120	min / test run
Duration of Test Runs	120	min /test run
Capture Efficiency of Ventilation System	100	%
Ventilation Rate	425	acfm
Air Agitation Rate	0	scfm
Air Agitation Rate per unit solution surface area	0	$scfm/ft^2$
Part Agitation Rate	77	in/min
Solution Circulation Rate	5 - 7	gpm (estimated)

Operating Conditions Recorded During Testing - No Air Agitation Run #3

Freeboard Height	4	inches
Plating Solution Temperature	122	°F
Plating Solution Nickel Content	10.3	oz/gal
Plating Solution Boric Acid Content	5.0	oz/gal
Plating Solution pH	3.5	pH
Plating Solution Surface Tension	37.9	dynes/cm
Plating Solution Specific Gravity	1.27	
Plating Voltage	6.6	volts
Average Amperage Applied	134	amperes
Calculated Ampere-hour Usage	268	A-hr
Calculated Current Density	23.0	A/ft^2
Number of Dummy Parts	4	plates
Total Surface Area of Plated Parts	5.82	ft^2
Plating Period within Test Run	120	min / test run
Duration of Test Runs	120	min /test run
Capture Efficiency of Ventilation System	100	%
Ventilation Rate	430	acfm
Air Agitation Rate	0	scfm
Air Agitation Rate per unit solution surface area	0	$scfm/ft^2$
Part Agitation Rate	77	in/min
Solution Circulation Rate	5 - 7	gpm (estimated)

TESTING METHODOLOGY

The testing consisted of two sets of triplicate two hour sampling runs with one set run under the air agitation operating condition and the second set run without the air agitation. The applied amperage during plating was obtained from a calibrated ammeter. The calibration certificate is included in the Appendix. The accuracy of the ammeter was checked by two means. A portable electrician's ammeter was used to verify the amperage at the rectifier. The resulting plating thickness was also checked by Mr. Sam Patel of California Technical Plating and verified to be that of the calculated resulting thickness for the plating time and amperage that were applied.

A temporary reduced draft ventilation system was designed and constructed both to isolate the process and collect the resulting nickel emissions in a manner to both facilitate the emissions measurement and to address concerns by the MFASC. The main MFASC concern is that a high flow ventilation system, such as a dedicated side-draft ventilation system may produce higher emissions due to entrainment of large splashed droplets that potentially fall back into the tanks or to the ground and may not become emissions to the atmosphere.

The temporary reduced draft system is designed to simulate emissions to the atmosphere of an unventilated tank. Mass emissions collected in the duct of a ventilated tank may be higher due to this effect. The temporary ventilation system consisted of cube shaped hood of similar cross sectional dimensions of the host tank. The hood was vented to a small blower which was set to achieve a specific velocity vertically through the hood. The hood was suspended at a height above the tank so that air also entered the hood from the space between the hood and the tank at a specified velocity. The height of the hood was 1.4 times the equivalent diameter of the tank cross section. A straight run of ducting between the hood and the blower was used to isolate and measure the emissions from the tank. A schematic of this system is shown in Figure 5. A photograph of the hood connected to the host tank is shown in Figure 6.

The appropriateness of the hood height was determined by a small scale 16"W x 20"L x 25"H hood connected to a small blower to simulate the full scale design. At a ventilation rate of 50 ft/min as determined by a calibrated vane anemometer, the height of the hood was sufficient to create a uniform velocity over the lower cross-section of the hood and maintain this uniformity for the lower one third of the hood. This was done to ensure that no high or low velocity zones were present as to defeat the purpose of the hood in its lower section.

As discussed in meetings with SCAQMD Methods and Testing staff and MFASC, the specific velocity was chosen to be approximately 50 ft/min. This specific velocity was chosen for the following reasons:

1. The velocity is considered as the minimum velocity at which 100% capture of actual emissions to the atmosphere can be achieved. This was verified using the small scale capture hood and a smoke test.

2. The velocity is sufficiently low as to not overestimate the range of velocities that may be encountered in a building that houses the process. This is important since these internal air currents are responsible for transporting the emissions to the atmosphere. For purposes of comparison, 50 ft/min equates to 0.57 miles per hour. Assuming that outdoor wind speeds typically vary from 3 -10 mph, it is not unreasonable to assume that 0.57 mph indoor air movements can be induced either by open doors, or the building's ventilation system.

3. According to the *American Conference of Governmental Industrial Hygienist Industrial Ventilation Manual*, 50 fpm is the indoor air speed created by an effective air conditioning system.

4. Calculations of settling velocity of small aerosols shows that small aerosol droplets less than 10 microns in diameter are capable of remaining airborne for several minutes, and much longer in moving air.

5. Past testing for cadmium emission factor has been successfully employed using a similar capture velocity.

Two large doors on the southwest side of the building provided a continuous stream of clean outside air to the tank area. The exhaust from the hood was directed towards a building ventilation blower so that the nickel was swept from the building to avoid the affects of hood exhaust recirculation. This air flow path was verified by smoke test.

SAMPLING AND ANALYTICAL PROCEDURES

Flow Rate

The gas velocity within the sampling duct was measured during each sampling run at eight points within the duct cross section according to SCAQMD Methods 1.2 and 2.3. This was performed simultaneously with the pollutant sampling using a NIST traceable standard type Pitot tube with a differential pressure manometer, and a type "K" thermocouple with a potentiometer (Figure 7). The apparatus was checked for leaks both before and after use by introducing a pressure head and blocking the flow at the Pitot tip. An observation of the resulting stabilization in pressure at the manometer verified the absence of leaks in the system. The stack's access ports were located using the approach of SCAQMD Method 2.3 for ducts of less than 12 inches in diameter. Using this approach, the sampling access ports were located approximately eight stack diameters downstream and greater than two stack diameters upstream from flow disturbances. The velocity access ports were located approximately five stack diameters downstream from the sampling access ports and greater than two stack diameters upstream from a flow disturbance. This configuration meets the minimum and most of the preferred SCAQMD Method 1.2 requirements for measurement site location.

A cyclonic flow check was also performed to check for the presence of flow that is non-parallel to the duct wall which can cause a bias in the flow measurement. This was accomplished by rotating an S-type Pitot tube at each traverse point until a zero pressure differential results at the gauge. The null angle is determined with an inclinometer as the deviation of the Pitot angle with respect to a plane perpendicular to the theoretically straight duct flow. Data from the cyclonic flow check shows that the duct does not exhibit cyclonic flow as defined in Method 1.1.

The volumetric flow rate was calculated for each sampling run using the stack's cross sectional area and average gas velocity. The flow rate was corrected to standard conditions by using the stack temperature and pressure along with the barometric pressure measured with a calibrated aneroid barometer. The flow rate was also corrected to dry conditions using the moisture content as determined by the SCAQMD Method 4.1 weight gain from the nickel sampling train as described in the following section.

Nickel Sampling - Modified CARB Method 433

A nickel sample was collected during each sampling run using Modified CARB Method 433. The modification was the same as that employed by MFASC contractor, PES, which consists of the use of a back-up filter as opposed to the up-front heated filter.

The sample was collected from the locations within the sampling duct previously described in the velocity measurements. Each sample was collected over a period of 120 minutes using a sampling train consisting of a glass probe and nozzle connected by a six to eight foot length of non-reactive tubing to the first of two Greenburg-Smith impingers each containing 100 ml of 0.1N nitric acid solution, an empty bubbler, a 0.5 micron glass fiber back-up filter, and a bubbler containing tared silica gel desiccant.

The impinger assembly was connected to a vacuum pump and a calibrated dry gas meter as shown in Figure 8. The sampling apparatus was checked for leaks both before and after sampling by blocking the flow at the probe tip. An observation of the resulting decrease in flow at the meter to less than 0.02 cfm or four percent of the sampling rate indicated an acceptable leak rate. The impinger train was contained within an ice bath to condense water and other condensable matter present in the sample stream.

The impinger train was returned to the SCAQMD laboratory for recovery. The recovered solutions were dissolved in concentrated nitric acid and boiled down according to CARB Method 433 and sent to West Coast Analytical Service, Inc. For analysis. Nickel collected in the nozzle, probe, impingers, and filter was determined using CARB Method 433 by Inductively Coupled Plasma Mass Spectrometry (ICPMS).

At the request of the MFASC, ambient sampling within the plating facility was conducted. The ambient samples were collected using the same configuration and analysis as that used for emissions sampling. The ambient samples were collected at a distance of approximately eight feet from the plating tank in the upwind direction with respect to airflow in the building at approximately the same height that the air entered the collection hood. The first ambient sample represents composite sampling of the ambient air during the air agitation runs and during the first of the non-air agitation runs. The second ambient sample represents composite sampling of the ambient air during the second two non-air agitation runs. A blank field sample train was also analyzed as above for quality control purposes.

Capture Efficiency

The capture efficiency was determined by a smoke test. The smoke test was accomplished using titanium chloride smoke generating tubes. This technique can be used to verify 100% capture or conversely less than 100% capture by observing the flow of the smoke into the capture hood. The observation of complete capture of the smoke indicated 100% capture efficiency. The smoke test was conducted at the perimeter of the tank between the temporary capture hood and the tank. Photographs of the actual smoke test are shown in Figure 9.

The height of the capture hood and the ventilation rates were adjusted in an attempt to achieve the 50 ft/min specified velocity vertically within the hood as well as to the sides of the hood. The actual velocities that were achieved during each sampling run were calculated from the ventilation flow rate and the cross sectional areas. The results of these calculations are presented in the following table:

Run #	Vent Velocity (fps)	Vertical Velocity in Hood (fpm)	Horizontal Velocity Between Hood and Tank (fpm)
Run #1 with Air	26.33	38.0	49.0
Run #2 with Air	28.18	40.6	52.4
Run #3 with Air	26.98	38.9	50.2
Run #1 no Air	26.86	38.7	50.0
Run #2 no Air	26.52	38.2	49.3
Run #3 no Air	26.83	38.7	49.9

Where:
Vent Cross Section (7.0" diameter) = 0.267 ft^2
Hood Cross Section (40" x 40")= 11.11 ft^2
Gap Cross Section (7.75" between hood and tank) = 8.61 ft^2
Vertical Velocity = Vent Velocity x 60 s/min x Vent Cross Section / Hood Cross Section
Horizontal Velocity = Vent Vel. x 60 s/min x Vent Cross Section / Gap Cross Section

Air Agitation Rate

In order to achieve the desired air agitation rate of 0.83 $acfm/ft^2_{tank}$, the air agitation valve was adjusted and the air agitation checked. This was repeated until the desired air agitation rate was achieved. This desired air agitation rate was then visually verified to be similar to that of the past MFASC testing by Mr. Dennis Becvar of PES who was present at both testing events.

To measure the air agitation rate, a five gallon plastic bucket was inverted and submerged to approximately one third of its height into the plating solution to create an air-tight seal at the bucket's perimeter. The bucket was moved across the surface of plating bath as to encompass the average air agitation rate in the tank while maintaining the bucket at a constant submersion height. A tap on the unsubmerged side of the bucket was connected to a calibrated gas meter to measure the volume of air collected in the bucket during which the elapsed time was also recorded. This technique was checked for accuracy in the laboratory by bubbling a known amount of air into the bottom of a water bath. The bucket technique was successful in duplicating the measurement of the gas metered into the bottom of the tank.

The air agitation rate as determined by this method was reported in units of scfm. Since a 60°F temperature compensated meter was used at atmospheric pressure, the readings were taken at very close to standard conditions. The moisture in the tank was, for the most part, condensed in the line between the bucket and the meter. A residual moisture, however, of approximately 2 - 5% remained in the metered air as it passed through the line. For this reason, the air agitation rate was not reported as a dry flow rate.

TEST CRITIQUE

The test was conducted under operating conditions so that the conditions of the past MFASC testing could be duplicated. A comparison to key operational parameters to the past MFASC testing are shown in the table below. It is assumed that these parameters were chosen by the MFASC to be representative of the nickel plating applications for which the emission factors are intended to be applied.

Process Parameter	MFASC Test	SCAQMD Test
Plating Current Density	17 amperes/ft^2_{parts}	24 amperes/ft^2_{parts}
Air Agitation Rate	0.83 acfm/ft^2_{tank} as measured by PES	0.88 acfm/ft^2_{tank} as measured by SCAQMD
Plating Solution Temperature	137-145 °F	119-123 °F
Plating Solution Nickel Content	10.3 - 12.6 oz/gal	10.4 oz/gal
Plating Solution Boric Acid Content	5.8 - 8.3 oz/gal	7.6 oz/gal
Plating Solution pH	3.4 - 4.3	2.0
Plating Solution Surface Tension	34.2 - 35.9 dynes/cm	37.9 dynes/cm
Number of Drag-Out Events per Run	6	6
Duration of Test Runs	120 min	120 min

The emissions for the air agitation runs were 3 times higher than the emissions without air agitation. The increase in measured emissions from the air agitated condition as compared to non-air agitated, is consistent with observations of the emissions characteristics of each condition. This difference in the emissions characteristics are consistent with the following observations comparing the agitated and non-agitated conditions:

1. Non-air agitated nickel plating has been observed to exhibit very little bubbling during plating due to a high efficiency of converting current to plating. This differs from chrome plating, where much bubbling is typically observed due to lower plating efficiency where much of the electrical current causes electrolysis of the plating

solution. As compared to the non-air agitated condition, the air agitation provides a great deal of turbulence to cause the formation of solution aerosol droplets. The difference between the two operating conditions is demonstrated in Figures 3 and 4.

2. A green nickel residue in the areas surrounding nickel plating tanks has been observed as accumulation in the facilities that employ air agitation. This residue has been observed within a large perimeter surrounding the plating tanks as well as high in the building on overhead pipes and ducting. This suggests that the aerosol droplets created by the air agitation can be sufficiently small so that they can be transported away from the immediate area of the tanks. Conversely, very little of this residue was observed at facilities that do not typically employ air agitation.

3. During testing it was observed that a burning sensation was experienced in the throat when breathing the blower effluent during air agitation. This observation was due to the acidic effects of the nickel plating solution on the throat while breathing. This observation did not occur when breathing the blower effluent during the non-air agitated condition. This indicates that a great deal more plating solution becomes airborne during air agitation.

Since the parts were not entirely submerged in the plating solution, the actual applied current density was calculated using the resulting plated surface area. Although the resulting current density of 23.0 - 24.4 A/ft^2 is higher than the target current density of 20 A/ft^2, it remains within the lower portion of the 20 - 50 A/ft^2 range specified as normal nickel plating in the *Electroplating Engineering Handbook.*

The measured ambient concentration for the air agitated condition was less than three percent of that measured for emissions sampling. The blank sample detection was 67% less than that detected in the ambient sample. The contribution of the blank and the ambient are therefore considered as insignificant for the sampling with air agitation.

For the air agitated condition, the precision of the sampling as indicated by the consistency of the triplicate sampling results is well within that which is generally experienced and considered acceptable for this type of sampling. For the non-air agitated condition, however, the precision of the sampling as indicated by the consistency of the triplicate sampling results is not within that which is generally considered acceptable for this type of sampling.

CONCLUSION

The results of the test during air agitation are considered as both sufficiently accurate and precise for use in determining nickel emission factors. The increase in measured emissions from the air agitated as compared to those measured during the non-air agitated condition is consistent with observations of the emissions characteristics of each condition. The results of the non-air agitation test, however, are considered to be less precise due to poor reproducibility of the triplicate runs.

Unlike the other tests in this project, a recommendation on the emission factor in which units would best represent actual emissions will not be made for this report. The reason for this is that, at the time of this report's issue, further testing is taking place. This additional testing is designed to address the precision problems and provide confirmation of the previous testing. Some guidance, however, is given as follows:

If the lb/hr-ft^2_{tank} factor is used, emissions would be determined by multiplying the factor by ft^2_{tank} as determined using the horizontal internal dimensions of a given tank, and also multiplied by the hours of air agitation for emissions during a specified time period. It is suggested that this factor is not well suited for non-air agitation applications due to the mechanism for the emissions being relatively independent of tank surface area.

If the lb/hr-ft^2_{parts} factor is used, emissions would be determined by multiplying the factor by ft^2_{parts} as determined using the average total surface of parts that are plated in the tank, and also multiplied by the hours of plating during a specified time period. It is suggested that this factor is not well suited for air agitation applications due to the mechanism for the emissions being relatively independent of part surface area.

If the lb/hr-$scfm_{air}$ factor is used, emissions would be determined by multiplying the factor by scfm of air agitation and also multiplied by the hours of air agitation for emissions during a specified time period. If the bucket method is used to determine the air agitation rate, the scfm/ft^2_{tank} result would be multiplied by the ft^2_{tank} as determined using the horizontal internal dimensions of a given tank to determine $scfm_{air}$. This factor would not be appropriate for non-air agitation applications.

The emission factors will not represent emissions from tanks that do not use a surface tension reducing agent that reduces to the 38.9 dyne/cm level encountered in this testing.

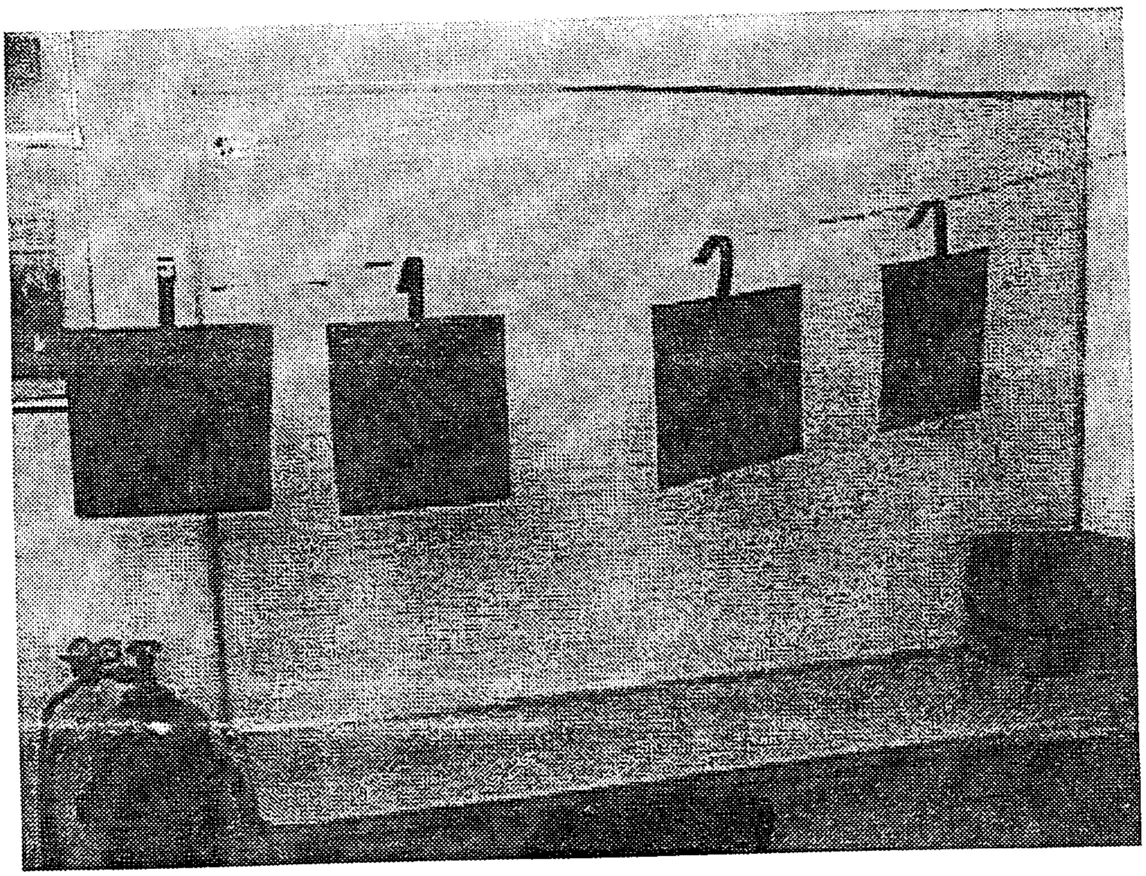


Figure 1 - Photograph of Dummy Parts

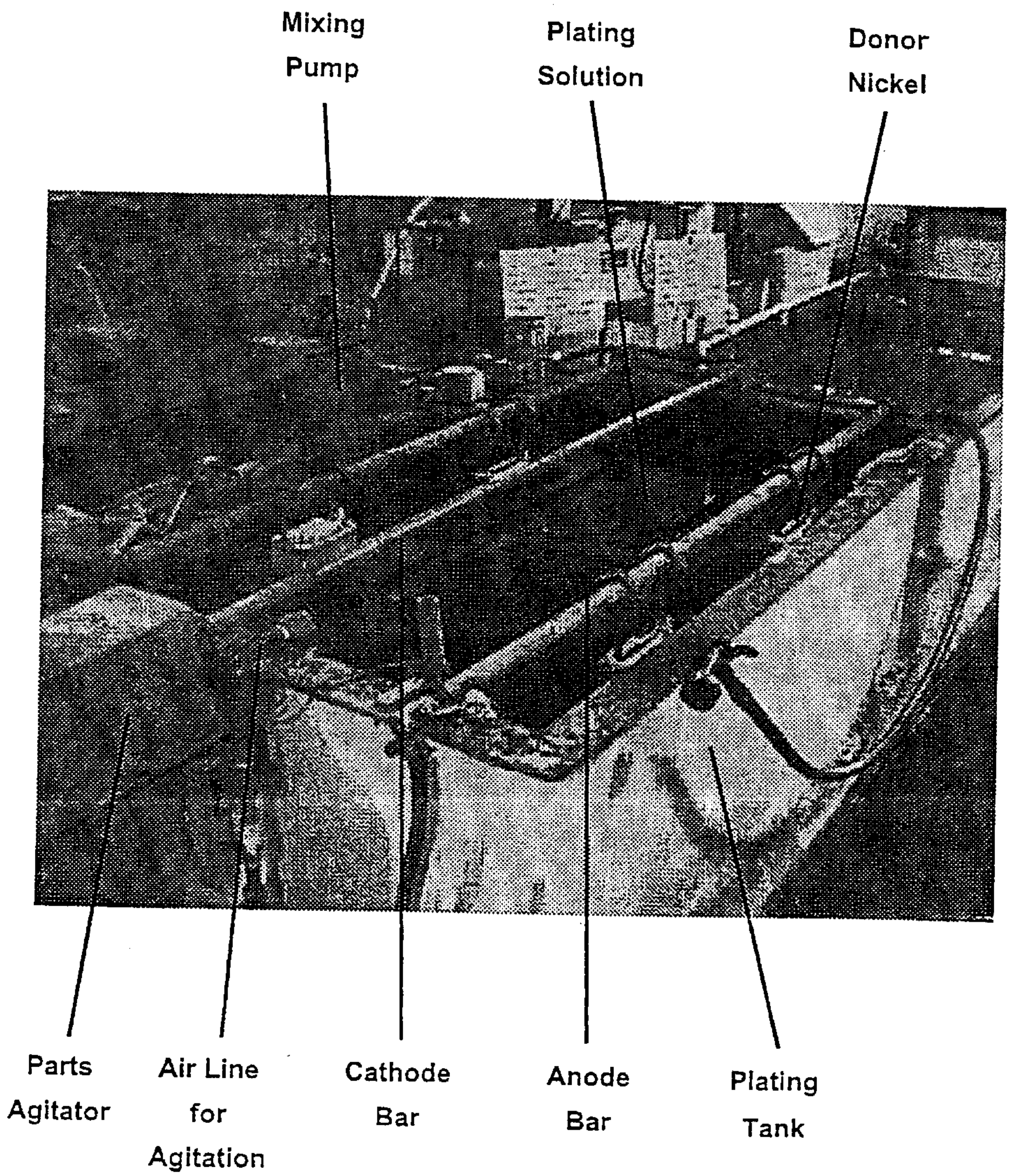


Figure 2 - Photograph of Host Nickel Plating Tank

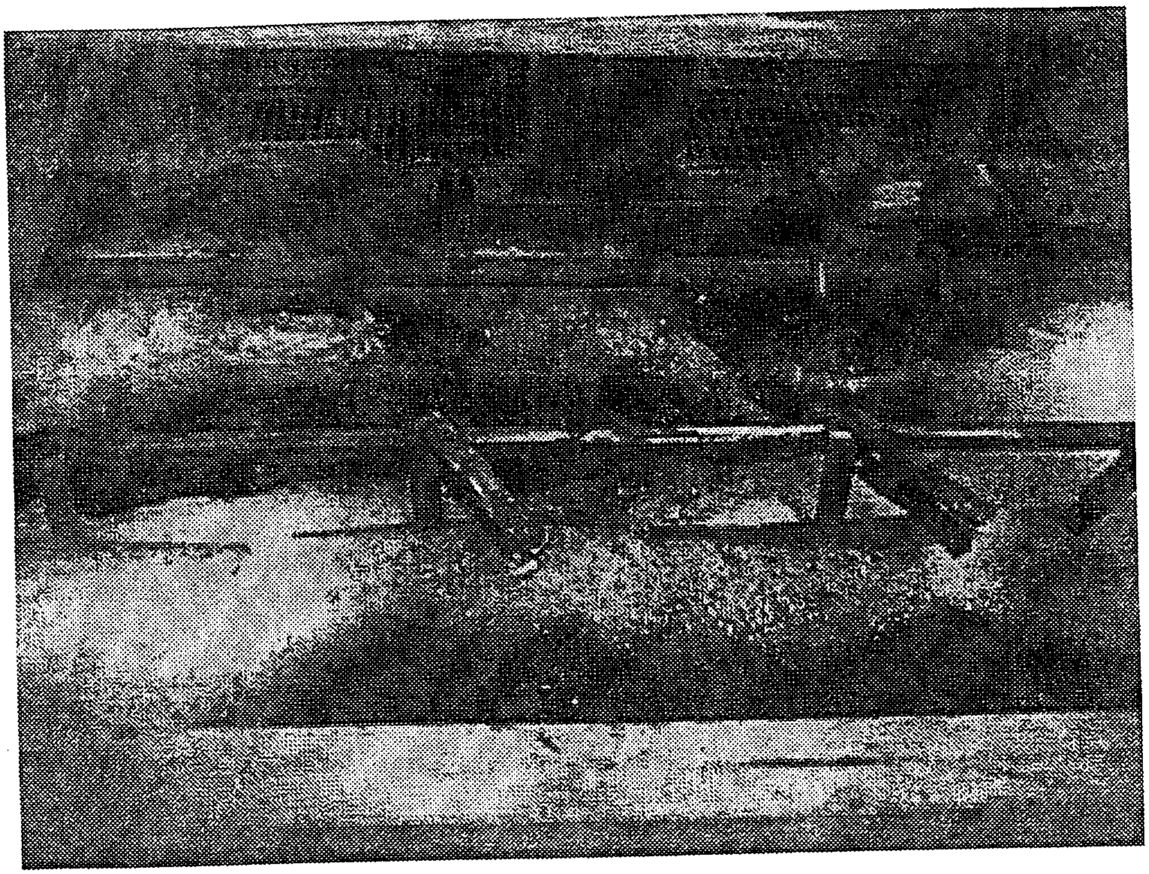


Figure 3 - Photograph of Active Plating Surface with Air Agitation

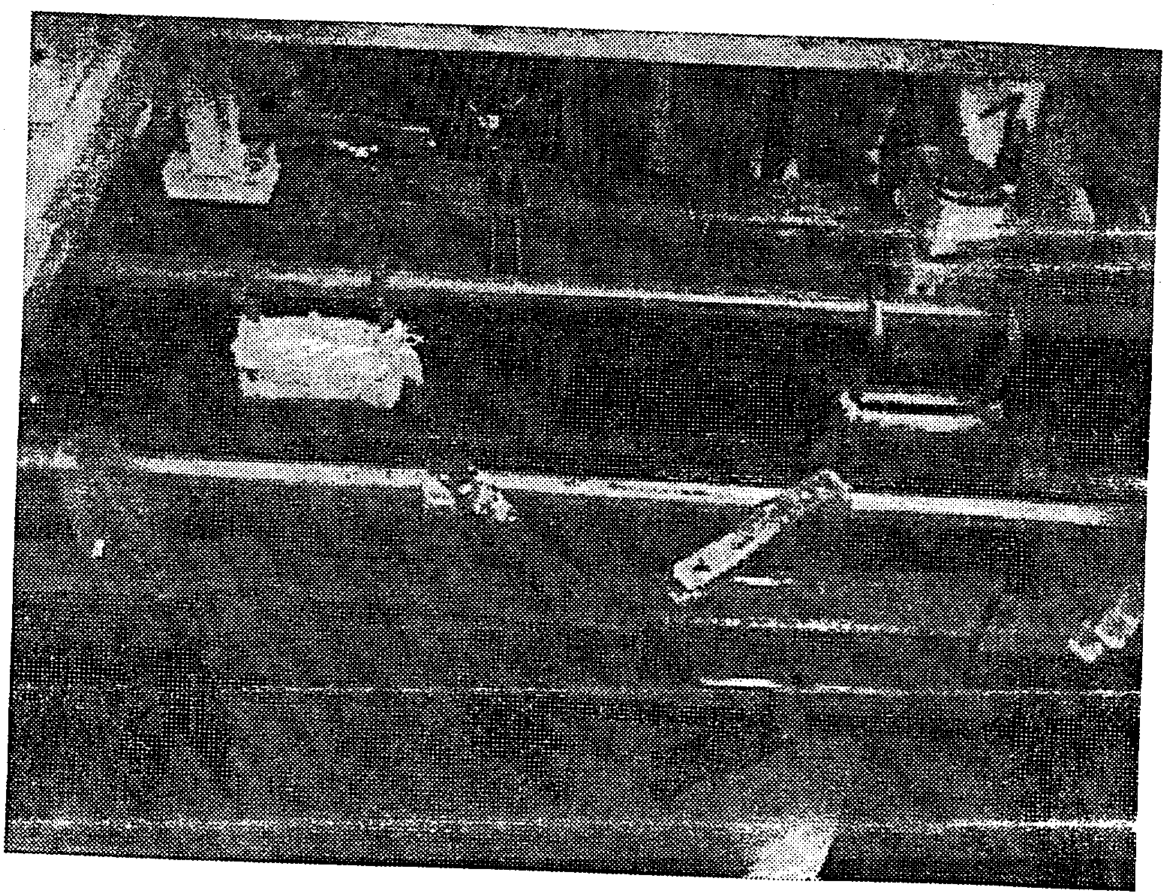


Figure 4 - Photograph of Active Plating Without Air Agitation

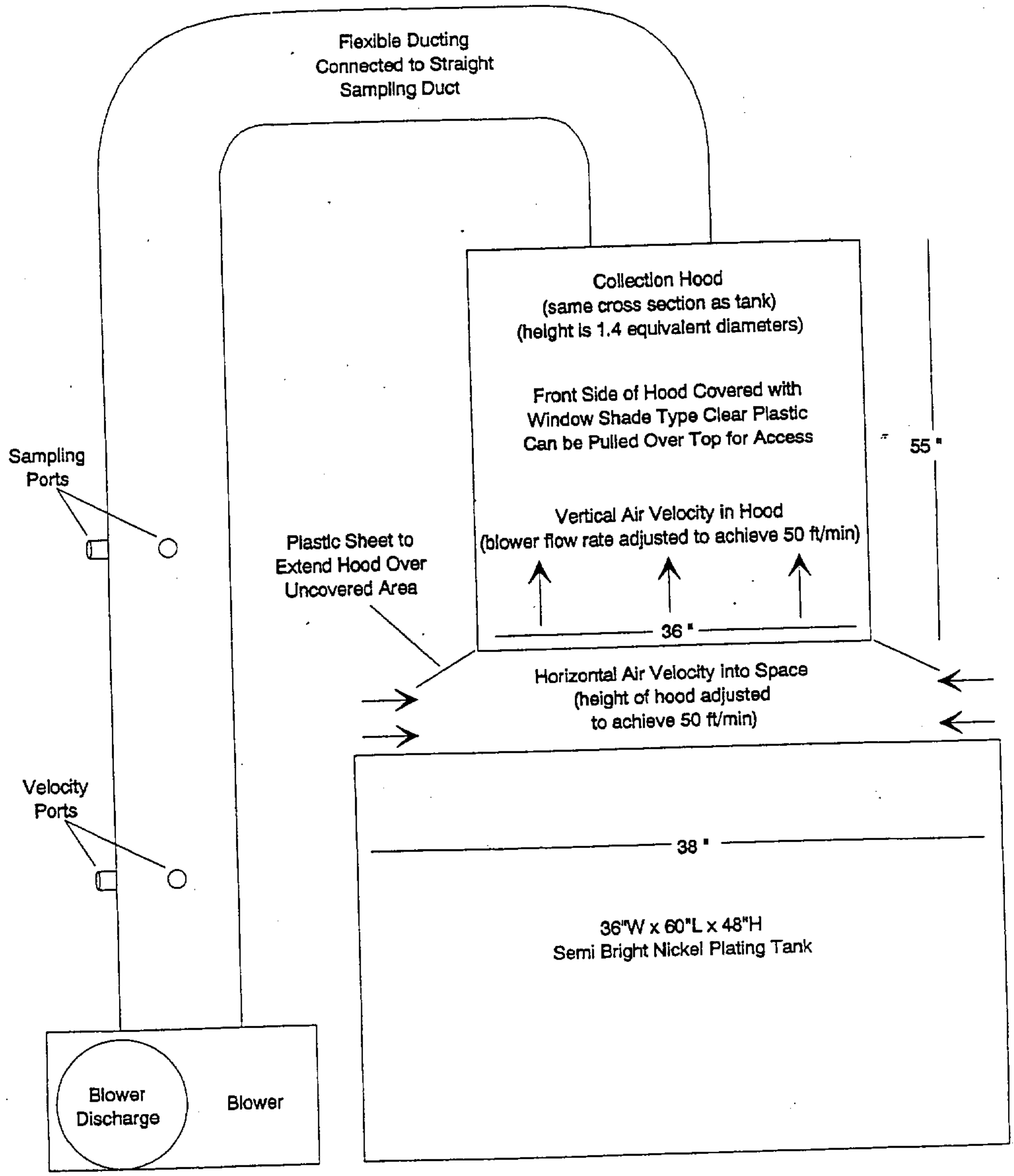


Figure 5 - Temporary Ventilation System with Sampling Location

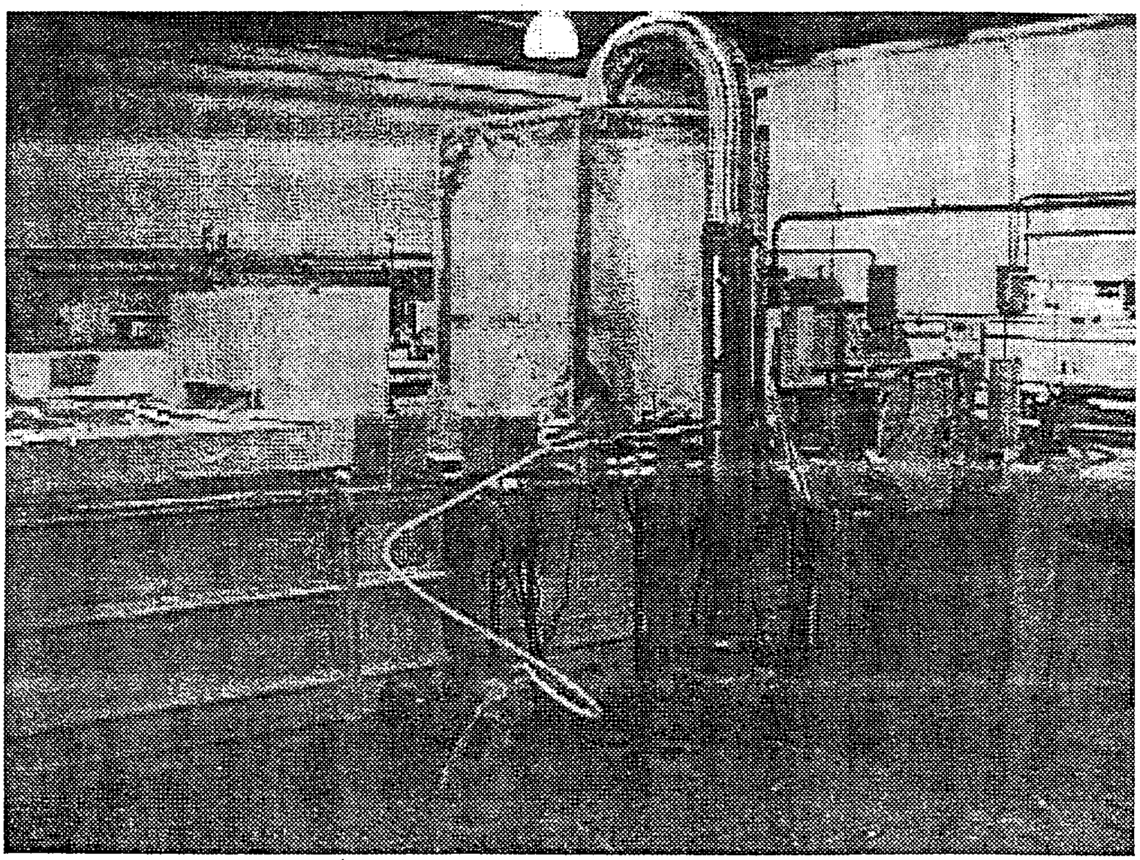
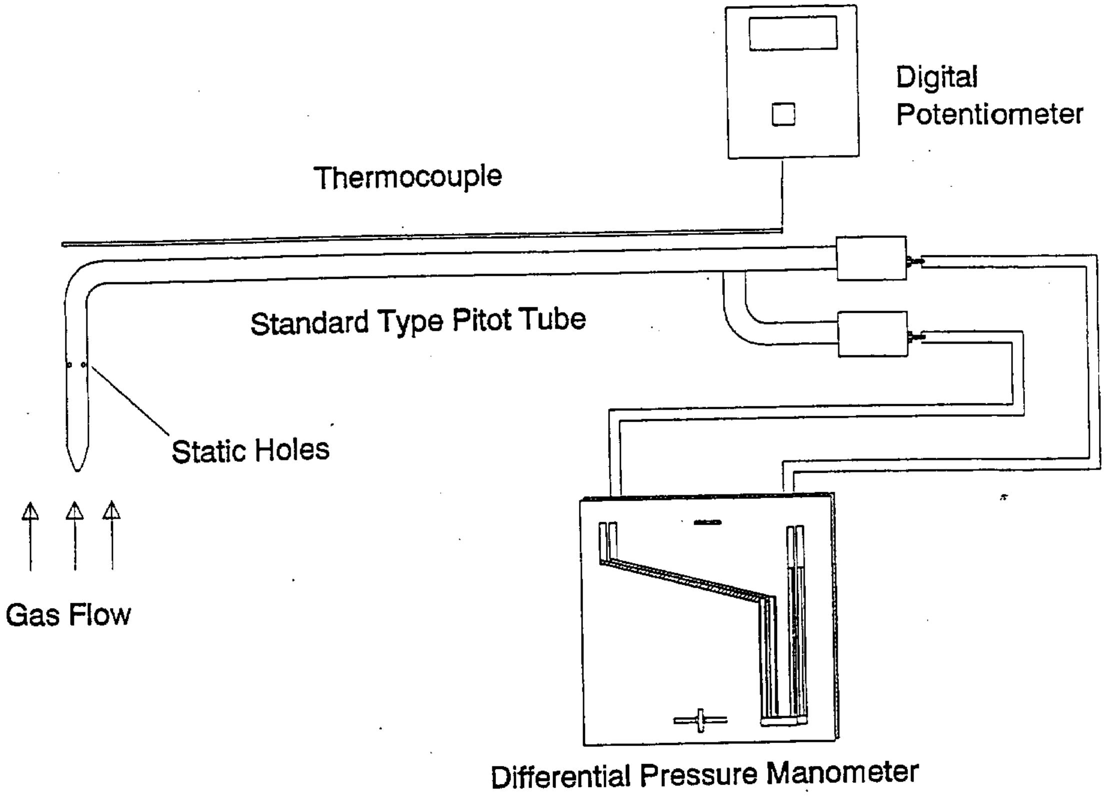
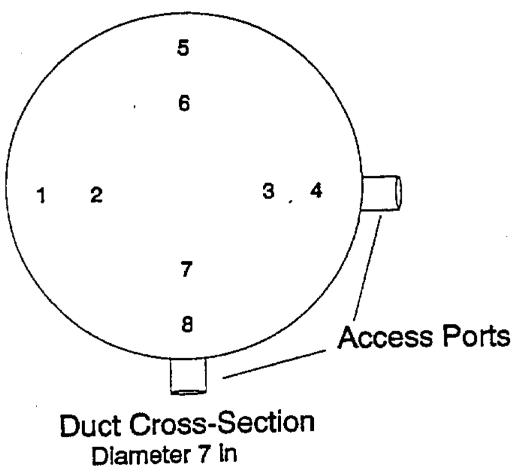


Figure 6 - Photograph of Temporary Ventilation System with Sampling Location





Traverse Point #	Distance from Inner Stack Wall (in)
1, 5	0.5
2, 6	1.75
3, 7	5.25
4, 8	6.5

Figure 7 - Flow Rate Measuring Apparatus

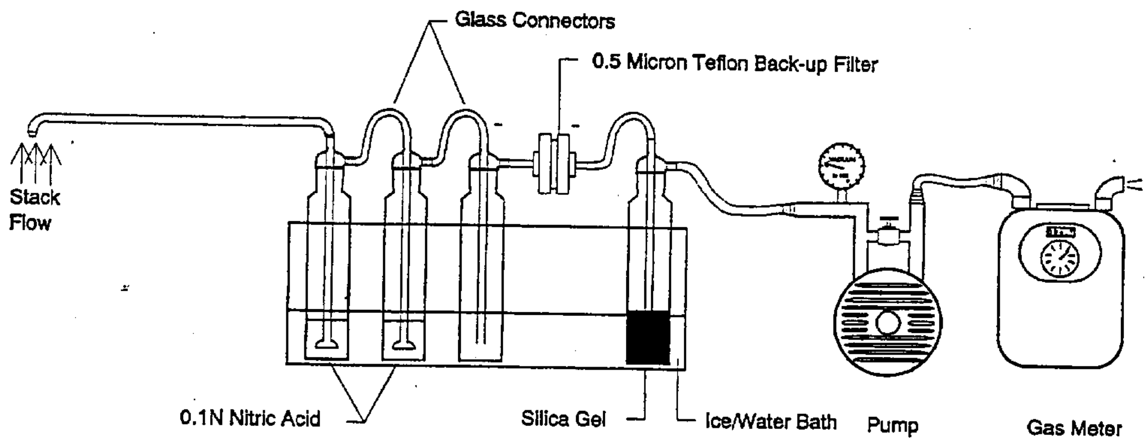


Figure 8 - Nickel Sampling Apparatus

Figure 9 - Photographs of Smoke Test for Capture Efficiency

SOURCE TEST CALCULATIONS

Average Velocity and Temperature

Run #1 with Air Agitation

Traverse Point #	Velocity Head #1 ("H_2O)	Temp. (°F)	Calculated Velocity (fps)
1	0.10	95	21.60
2	0.14	95	25.56
3	0.15	92	26.39
4	0.15	90	26.34
5	0.15	91	26.36
6	0.14	91	25.47
7	0.15	90	26.34
8	0.16	90	27.20
Average Velocity (fps)			25.66
Average Temperature (°F) -		91.75	

Run #2 with Air Agitation

Traverse Point #	Velocity Head #1 ("H_2O)	Temp. (°F)	Calculated Velocity (fps)
1	0.14	90	25.45
2	0.19	91	29.67
3	0.16	90	27.20
4	0.18	90	28.85
5	0.14	90	25.45
6	0.18	90	28.85
7	0.15	90	26.34
8	0.17	89	28.02
Average Velocity (fps)			27.48
Average Temperature (°F) -		90	

Where: Calculated Velocity = 2.9 x [Velocity Head x (460 + Temperature)]$^{0.5}$

SOURCE TEST CALCULATIONS

Average Velocity and Temperature

Run #3 with Air Agitation

Traverse Point #	Velocity Head #1 ("H_2O)	Temp. (°F)	Calculated Velocity (fps)
1	0.14	81	25.24
2	0.16	82	27.01
3	0.18	82	28.64
4	0.14	81	25.24
5	0.14	80	25.21
6	0.17	81	27.81
7	0.16	81	26.98
8	0.14	80	25.21
Average Velocity (fps)			26.42
Average Temperature (°F) -		81	

Run #1 No Air Agitation

Traverse Point #	Velocity Head #1 ("H_2O)	Temp. (°F)	Calculated Velocity (fps)
1	0.17	83	27.86
2	0.16	80	26.96
3	0.14	83	25.28
4	0.12	80	23.34
5	0.14	80	25.21
6	0.16	83	27.03
7	0.16	82	27.01
8	0.17	83	27.86
Average Velocity (fps)			26.32
Average Temperature (°F) -		81.75	

Where: Calculated Velocity = 2.9 x [Velocity Head x (460 + Temperature)]$^{0.5}$

SOURCE TEST CALCULATIONS

Average Velocity and Temperature

Run #2 No Air Agitation

Traverse Point #	Velocity Head #1 ("H_2O)	Temp. (°F)	Calculated Velocity (fps)
1	0.12	90	23.56
2	0.14	91	25.47
3	0.18	90	28.85
4	0.16	90	27.20
5	0.13	89	24.50
6	0.15	90	26.34
7	0.15	90	26.34
8	0.14	91	25.47
Average Velocity (fps)			25.97
Average Temperature (°F) -			90.125

Run #3 No Air Agitation

Traverse Point #	Velocity Head #1 ("H_2O)	Temp. (°F)	Calculated Velocity (fps)
1	0.11	90	22.56
2	0.14	90	25.45
3	0.16	90	27.20
4	0.21	89	31.14
5	0.11	89	22.54
6	0.16	89	27.18
7	0.16	87	27.13
8	0.16	85	27.08
Average Velocity (fps)			26.28
Average Temperature (°F) -			88.625

Where: Calculated Velocity = 2.9 x [Velocity Head x (460 + Temperature)]$^{0.5}$

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SOURCE TEST CALCULATIONS
Flow Rate and Emissions for Run #1 with Air Agitation

Sample Train: Nickel Train #5 Input by: M.Garibay

SUMMARY

A. Average Traverse Velocity	25.66 fps
B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters)	100.3 deg F
C. Gas Meter Correction Factor	1.0042
D. Average Orifice Pressure	2.04 "H20
E. Nozzle Diameter	0.3212 inch

F1. Stack Dimension #1	7 inch		
F2. Stack Dimension #2	inch	M. Pitot Correction Factor	1.00
G. Stack Cross Sect. Area	0.267 ft2	N. Sampling Time	120 min
H. Average Stack Temp	91.8 deg F	O. Nozzle X-Sect. Area	0.00056 ft
I. Barometric Pressure	28.70 "HgA	P. Sample Collection	0.153 mg
J. Gas Meter Pressure (I+(D/13.6	28.85 "HgA	Q. Sample Collection	0.153 mg
K. Static Pressure	-0.41 "H20	R. Water Vapor Condensed	56.3 ml
L. Total Stack Pressure (I+(K/13.	28.67 "HgA	S. Gas Volume Metered	101.067 dcf

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C ... 90.823 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) ... 2.80 %

V. Average Molecular Weight (Wet):

Component	Vol. Fract.		x	Moist. Fract.	x	Molecular Wt.	=	Wt./
Water	0.028			1.000		18.0	,	0.50
Carbon Dioxide	0.000	Dry Basis		0.972		44.0	,	0.02
Carbon Monoxide	0.000	Dry Basis		0.972		28.0	,	0.00
Oxygen	0.209	Dry Basis		0.972		32.0	,	6.50
Nitrogen & Inerts	0.791	Dry Basis		0.972		28.2	,	21.67
							Sum	28.69

FLOW RATE

W. Gas Density Correction Factor (28.95/V)^.5	1.00
X. Velocity Pressure Correction Factor (29.92/L)^.5	1.02
Y. Corrected Velocity (A x M x W x X)	26.33 fps
Z. Flow Rate (Y x G x 60)	422 cfm
AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]}	381 scfm
BB. Dry Flow Rate (AA x (U/100))	371 dscfm

SAMPLE CONCENTRATION/EMISSION RATE

CC. Sample Concentration [0.01543 x (P/T)]	2.60E-05 gr/dscf
DD. Sample Conc. [54,143xCC/ 58.7 (Molecular Wt.)]	0.02398 ppm
EE. Nickel Emission Rate (0.00857 x BB xCC)	8.26E-05 lb/hr
FF. Nickel Emission Rate [(.0001322 x Q x BB)/T]	8.25E-05 lb/hr
GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)]	97.0 %

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SOURCE TEST CALCULATIONS
Flow Rate and Emissions for Run #2 with Air Agitation

Sample Train: Nickel Train #14 Input by: M.Garibay

SUMMARY

A. Average Traverse Velocity	27.48	fps
B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters)	102.8	deg F
C. Gas Meter Correction Factor	1.0042	
D. Average Orifice Pressure	2.12	"H20
E. Nozzle Diameter	0.3125	inch

F1. Stack Dimension #1	7	inch			
F2. Stack Dimension #2		inch	M. Pitot Correction Factor	1.00	
G. Stack Cross Sect. Area	0.267	ft2	N. Sampling Time	120	min
H. Average Stack Temp	90.0	deg F	O. Nozzle X-Sect. Area	0.00053	ft
I. Barometric Pressure	28.70	"HgA	P. Sample Collection	0.172	mg
J. Gas Meter Pressure (I+(D/13.6	28.86	"HgA	Q. Sample Collection	0.172	mg
K. Static Pressure	-0.41	"H20	R. Water Vapor Condensed	50.6	ml
L. Total Stack Pressure (I+(K/13.	28.67	"HgA	S. Gas Volume Metered	101.190	dcf

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C .... 90.548 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) .... 2.53 %

V. Average Molecular Weight (Wet):

Component	Vol. Fract.		x Moist. Fract.	x Molecular Wt.	= Wt./
Water	0.025		1.000	18.0	0.45
Carbon Dioxide	0.000	Dry Basis	0.975	44.0	0.02
Carbon Monoxide	0.000	Dry Basis	0.975	28.0	0.00
Oxygen	0.209	Dry Basis	0.975	32.0	6.52
Nitrogen & Inerts	0.791	Dry Basis	0.975	28.2	21.73
				Sum	28.72

FLOW RATE

W. Gas Density Correction Factor (28.95/V)^.5	1.00	
X. Velocity Pressure Correction Factor (29.92/L)^.5	1.02	
Y. Corrected Velocity (A x M x W x X)	28.18	fps
Z. Flow Rate (Y x G x 60)	452	cfm
AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]}	409	scfm
BB. Dry Flow Rate (AA x (U/100))	399	dscfm

SAMPLE CONCENTRATION/EMISSION RATE

CC. Sample Concentration [0.01543 x (P/T)]	2.93E-05	gr/dscf
DD. Sample Conc. [54,143xCC/ 58.7 (Molecular Wt.)]	0.02703	ppm
EE. Nickel Emission Rate (0.00857 x BB xCC)	1.00E-04	lb/hr
FF. Nickel Emission Rate [(.0001322 x Q x BB)/T]	1.00E-04	lb/hr
GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)]	94.9	%

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SOURCE TEST CALCULATIONS
Flow Rate and Emissions for Run #3 with Air Agitation

Sample Train: Nickel Train #15 Input by: M.Garibay

SUMMARY

A. Average Traverse Velocity	26.42	fps
B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters)	87.6	deg F
C. Gas Meter Correction Factor	1.0042	
D. Average Orifice Pressure	0.79	"H20
E. Nozzle Diameter	0.2500	inch

F1. Stack Dimension #1	7 inch				
F2. Stack Dimension #2	inch		M. Pitot Correction Factor	1.00	
G. Stack Cross Sect. Area	0.267	ft2	N. Sampling Time	120	min
H. Average Stack Temp.	81.0	deg F	O. Nozzle X-Sect. Area	0.00034	ft
I. Barometric Pressure	28.95	"HgA	P. Sample Collection	0.0578	mg
J. Gas Meter Pressure (I+(D/13.6	29.01	"HgA	Q. Sample Collection	0.0578	mg
K. Static Pressure	-0.37	"H20	R. Water Vapor Condensed	33.5	ml
L. Total Stack Pressure (I+(K/13.	28.92	"HgA	S. Gas Volume Metered	62.388	dcf

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C ..... 57.679 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) ..... 2.62 %

V. Average Molecular Weight (Wet):

Component	Vol. Fract.	x	Moist. Fract.	x	Molecular Wt.	=	Wt./
Water	0.026		1.000		18.0	,	0.47
Carbon Dioxide	0.000	Dry Basis	0.974		44.0	,	0.02
Carbon Monoxide	0.000	Dry Basis	0.974		28.0	,	0.00
Oxygen	0.209	Dry Basis	0.974		32.0	,	6.51
Nitrogen & Inerts	0.791	Dry Basis	0.974		28.2	,	21.71
						Sum	28.71

FLOW RATE

W. Gas Density Correction Factor (28.95/V)^.5	1.00	
X. Velocity Pressure Correction Factor (29.92/L)^.5	1.02	
Y. Corrected Velocity (A x M x W x X)	26.98	fps
Z. Flow Rate (Y x G x 60)	433	cfm
AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]}	402	scfm
BB. Dry Flow Rate (AA x (U/100))	391	dscfm

SAMPLE CONCENTRATION/EMISSION RATE

CC. Sample Concentration [0.01543 x (P/T)]	1.55E-05	gr/dscf
DD. Sample Conc. [54,143xCC/ 58.7 (Molecular Wt.)]	0.01426	ppm
EE. Nickel Emission Rate (0.00857 x BB xCC)	5.19E-05	lb/hr
FF. Nickel Emission Rate [(.0001322 x Q x BB)/T]	5.19E-05	lb/hr
GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)]	96.3	%

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SOURCE TEST CALCULATIONS
Emissions for Ambient with Air Agitation

Sample Train: Nickel Train #7

Input by: M.Garibay

SUMMARY

A. Average Traverse Velocity		fps
B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters)	98.2	deg F
C. Gas Meter Correction Factor	1.0023	
D. Average Orifice Pressure	2.35	"H20
E. Nozzle Diameter		inch

F1. Stack Dimension #1		inch			
F2. Stack Dimension #2		inch	M. Pitot Correction Factor		
G. Stack Cross Sect. Area		ft2	N. Sampling Time	510	min
H. Average Stack Temp		deg F	O. Nozzle X-Sect. Area		ft
I. Barometric Pressure	28.70	"HgA	P. Sample Collection	0.0084	mg
J. Gas Meter Pressure (I+(D/13.6	28.87	"HgA	Q. Sample Collection	0.0084	mg
K. Static Pressure		"H20	R. Water Vapor Condensed	120.1	ml
L. Total Stack Pressure (I+(K/13.		"HgA	S. Gas Volume Metered	431.413	dcf

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C .... 388.715 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) .... 1.41 %

V. Average Molecular Weight (Wet):

Component	Vol. Fract.		x Moist. Fract.	x Molecular Wt.	= Wt./
Water	0.014		1.000	18.0	0.25
Carbon Dioxide	0.000	Dry Basis	0.986	44.0	0.02
Carbon Monoxide	0.000	Dry Basis	0.986	28.0	0.00
Oxygen	0.209	Dry Basis	0.986	32.0	6.59
Nitrogen & Inerts	0.791	Dry Basis	0.986	28.2	21.98
				Sum	28.85

FLOW RATE

W. Gas Density Correction Factor (28.95/V)^.5	1.00	
X. Velocity Pressure Correction Factor (29.92/L)^.5		
Y. Corrected Velocity (A x M x W x X)		fps
Z. Flow Rate (Y x G x 60)		cfm
AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]}		scfm
BB. Dry Flow Rate (AA x (U/100))		dscfm

SAMPLE CONCENTRATION/EMISSION RATE

CC. Sample Concentration [0.01543 x (P/T)]	3.33E-07	gr/dscf
DD. Sample Conc. [54,143xCC/ 58.7 (Molecular Wt.)]	0.00031	ppm
EE. Nickel Emission Rate (0.00857 x BB xCC)		lb/hr
FF. Nickel Emission Rate [(.0001322 x Q x BB)/T]		lb/hr
GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)]		%

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Air Quality Management District
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SOURCE TEST CALCULATIONS
Flow Rate and Emissions for Run #1 No Air Agitation

Sample Train: Nickel Train #4 Input by: M.Garibay

SUMMARY

A. Average Traverse Velocity	26.32	fps
B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters)	85.3	deg F
C. Gas Meter Correction Factor	1.0042	
D. Average Orifice Pressure	1.99	"H20
E. Nozzle Diameter	0.3168	inch

F1. Stack Dimension #1	7	inch	M. Pitot Correction Factor	1.00	
F2. Stack Dimension #2		inch	N. Sampling Time	120	min
G. Stack Cross Sect. Area	0.267	ft2	O. Nozzle X-Sect. Area	0.00055	ft
H. Average Stack Temp	81.8	deg F	P. Sample Collection	0.0041	mg
I. Barometric Pressure	28.95	"HgA	Q. Sample Collection	0.0041	mg
J. Gas Meter Pressure (I+(D/13.6	29.10	"HgA	R. Water Vapor Condensed	45.9	ml
K. Static Pressure	-0.40	"H20	S. Gas Volume Metered	99.153	dcf
L. Total Stack Pressure (I+(K/13.	28.92	"HgA			

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C .... 92.336 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) .... 2.25 %

V. Average Molecular Weight (Wet):

Component	Vol. Fract.		x	Moist. Fract.	x	Molecular Wt.	=	Wt./
Water	0.023			1.000		18.0		0.41
Carbon Dioxide	0.000	Dry Basis		0.977		44.0		0.02
Carbon Monoxide	0.000	Dry Basis		0.977		28.0		0.00
Oxygen	0.209	Dry Basis		0.977		32.0		6.54
Nitrogen & Inerts	0.791	Dry Basis		0.977		28.2		21.79
							Sum	28.75

FLOW RATE

W. Gas Density Correction Factor (28.95/V)^.5	1.00	
X. Velocity Pressure Correction Factor (29.92/L)^.5	1.02	
Y. Corrected Velocity (A x M x W x X)	26.86	fps
Z. Flow Rate (Y x G x 60)	431	cfm
AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]}	400	scfm
BB. Dry Flow Rate (AA x (U/100))	391	dscfm

SAMPLE CONCENTRATION/EMISSION RATE

CC. Sample Concentration [0.01543 x (P/T)]	6.85E-07	gr/dscf
DD. Sample Conc. [54,143xCC/ 58.7 (Molecular Wt.)]	0.00063	ppm
EE. Nickel Emission Rate (0.00857 x BB xCC)	2.29E-06	lb/hr
FF. Nickel Emission Rate [(.0001322 x Q x BB)/T]	2.29E-06	lb/hr
GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)]	96.2	%

South Coast
Air Quality Management District
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SOURCE TEST CALCULATIONS
Flow Rate and Emissions for Run #2 No Air Agitation

Sample Train: Nickel Train #12 Input by: M.Garibay

SUMMARY

A. Average Traverse Velocity	25.97	fps
B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters)	94.6	deg F
C. Gas Meter Correction Factor	1.0023	
D. Average Orifice Pressure	2.08	"H20
E. Nozzle Diameter	0.3125	inch

F1. Stack Dimension #1	7	inch			
F2. Stack Dimension #2		inch	M. Pitot Correction Factor	1.00	
G. Stack Cross Sect. Area	0.267	ft2	N. Sampling Time	120	min
H. Average Stack Temp.	90.1	deg F	O. Nozzle X-Sect. Area	0.00053	ft
I. Barometric Pressure	28.85	"HgA	P. Sample Collection	0.0734	mg
J. Gas Meter Pressure (I+(D/13.6	29.00	"HgA	Q. Sample Collection	0.0734	mg
K. Static Pressure	-0.40	"H20	R. Water Vapor Condensed	32.3	ml
L. Total Stack Pressure (I+(K/13.	28.82	"HgA	S. Gas Volume Metered	95.502	dcf

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C .... 86.999 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) .... 1.69 %

V. Average Molecular Weight (Wet):

Component	Vol. Fract.	x	Moist. Fract.	x	Molecular Wt.	=	Wt./
Water	0.017		1.000		18.0	,	0.30
Carbon Dioxide	0.000	Dry Basis	0.983		44.0	,	0.02
Carbon Monoxide	0.000	Dry Basis	0.983		28.0	,	0.00
Oxygen	0.209	Dry Basis	0.983		32.0	,	6.57
Nitrogen & Inerts	0.791	Dry Basis	0.983		28.2	,	21.92
					Sum		28.81

FLOW RATE

W. Gas Density Correction Factor (28.95/V)^.5	1.00	
X. Velocity Pressure Correction Factor (29.92/L)^.5	1.02	
Y. Corrected Velocity (A x M x W x X)	26.52	fps
Z. Flow Rate (Y x G x 60)	425	cfm
AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]}	387	scfm
BB. Dry Flow Rate (AA x (U/100))	381	dscfm

SAMPLE CONCENTRATION/EMISSION RATE

CC. Sample Concentration [0.01543 x (P/T)]	1.30E-05	gr/dscf
DD. Sample Conc. [54,143xCC/ 58.7 (Molecular Wt.)]	0.01201	ppm
EE. Nickel Emission Rate (0.00857 x BB xCC)	4.25E-05	lb/hr
FF. Nickel Emission Rate [(.0001322 x Q x BB)/T]	4.25E-05	lb/hr
GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)]	95.6	%

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SOURCE TEST CALCULATIONS
Flow Rate and Emissions for Run #3 No Air Agitation

Sample Train: Nickel Train #10

Input by: M.Garibay

SUMMARY

A. Average Traverse Velocity	26.28	fps
B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters)	98.7	deg F
C. Gas Meter Correction Factor	1.0023	
D. Average Orifice Pressure	2.31	"H20
E. Nozzle Diameter	0.3168	inch

F1. Stack Dimension #1	7	inch	M. Pitot Correction Factor	1.00	
F2. Stack Dimension #2		inch	N. Sampling Time	120	min
G. Stack Cross Sect. Area	0.267	ft2	O. Nozzle X-Sect. Area	0.00055	ft
H. Average Stack Temp	88.6	deg F	P. Sample Collection	0.0634	mg
I. Barometric Pressure	28.85	"HgA	Q. Sample Collection	0.0634	mg
J. Gas Meter Pressure (I+(D/13.6	29.02	"HgA	R. Water Vapor Condensed	26.2	ml
K. Static Pressure	-0.37	"H20	S. Gas Volume Metered	100.637	dcf
L. Total Stack Pressure (I+(K/13.	28.82	"HgA			

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C .... 91.057 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) .... 1.32 %

V. Average Molecular Weight (Wet):

Component	Vol. Fract.	x	Moist. Fract.	x	Molecular Wt.	=	Wt./
Water	0.013		1.000		18.0	,	0.24
Carbon Dioxide	0.000	Dry Basis	0.987		44.0	,	0.02
Carbon Monoxide	0.000	Dry Basis	0.987		28.0	,	0.00
Oxygen	0.209	Dry Basis	0.987		32.0	,	6.60
Nitrogen & Inerts	0.791	Dry Basis	0.987		28.2	,	22.00
						Sum	28.86

FLOW RATE

W. Gas Density Correction Factor (28.95/V)^.5	1.00	
X. Velocity Pressure Correction Factor (29.92/L)^.5	1.02	
Y. Corrected Velocity (A x M x W x X)	26.82	fps
Z. Flow Rate (Y x G x 60)	430	cfm
AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]}	393	scfm
BB. Dry Flow Rate (AA x (U/100))	388	dscfm

SAMPLE CONCENTRATION/EMISSION RATE

CC. Sample Concentration [0.01543 x (P/T)]	1.07E-05	gr/dscf
DD. Sample Conc. [54,143xCC/ 58.7 (Molecular Wt.)]	0.00991	ppm
EE. Nickel Emission Rate (0.00857 x BB xCC)	3.57E-05	lb/hr
FF. Nickel Emission Rate [(.0001322 x Q x BB)/T]	3.57E-05	lb/hr
GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)]	95.6	%

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SOURCE TEST CALCULATIONS
Emissions for Ambient No Air Agitation

Sample Train: Nickel Train #13

Input by: M.Garibay

SUMMARY

A. Average Traverse Velocity		fps
B. Gas Meter Temperature (Use 60 deg.F for Temp Comp. Meters)	96.5	deg F
C. Gas Meter Correction Factor	1.0042	
D. Average Orifice Pressure	2.50	"H20
E. Nozzle Diameter		inch

F1. Stack Dimension #1		inch			
F2. Stack Dimension #2		inch	M. Pitot Correction Factor		
G. Stack Cross Sect. Area		ft2	N. Sampling Time	255	min
H. Average Stack Temp		deg F	O. Nozzle X-Sect. Area		ft
I. Barometric Pressure	28.85	"HgA	P. Sample Collection	0.005	mg
J. Gas Meter Pressure (I+(D/13.6	29.03	"HgA	Q. Sample Collection	0.005	mg
K. Static Pressure		"H20	R. Water Vapor Condensed	25.4	ml
L. Total Stack Pressure (I+(K/13.		"HgA	S. Gas Volume Metered	231.455	dcf

T. Corrected Gas Volume [(S x J/29.92) x 520/(460+B) x C .... 210.750 dscf

PERCENT MOISTURE/GAS DENSITY

U. Percent Water Vapor in Gas Sample ((4.64 x R)/((0.0464 x R) + T)) .... 0.56 %

V. Average Molecular Weight (Wet):

Component	Vol. Fract.		x	Moist. Fract.	x	Molecular Wt.	=	Wt./
Water	0.006			1.000		18.0		0.10
Carbon Dioxide	0.000	Dry Basis		0.994		44.0		0.02
Carbon Monoxide	0.000	Dry Basis		0.994		28.0		0.00
Oxygen	0.209	Dry Basis		0.994		32.0		6.65
Nitrogen & Inerts	0.791	Dry Basis		0.994		28.2		22.17
						Sum		28.94

FLOW RATE

W. Gas Density Correction Factor (28.95/V)^.5	1.00	
X. Velocity Pressure Correction Factor (29.92/L)^.5		
Y. Corrected Velocity (A x M x W x X)		fps
Z. Flow Rate (Y x G x 60)		cfm
AA. Flow Rate (Standard) {Z x (L/29.92) x [520/(460+H)]}		scfm
BB. Dry Flow Rate (AA x (U/100))		dscfm

SAMPLE CONCENTRATION/EMISSION RATE

CC. Sample Concentration [0.01543 x (P/T)]	3.66E-07	gr/dscf
DD. Sample Conc. [54,143xCC/ 58.7 (Molecular Wt.)]	0.00034	ppm
EE. Nickel Emission Rate (0.00857 x BB xCC)		lb/hr
FF. Nickel Emission Rate [(.0001322 x Q x BB)/T]		lb/hr
GG. Isokinetic Sampling Rate [(G x T x 100)/(N x O x BB)]		%

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Air Quality Management District
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SOURCE TEST CALCULATIONS
Unit Conversions

Run #	lb/hr	lb/hr-ft2 tank	lb/hr-ft2 parts	lb/hr-cfmair	gr/dscf	mg/dscm	mg/hr	amperes	mg/A-hr
1 air	8.26E-05	5.51E-06	1.42E-05	6.33E-06	2.60E-05	5.95E-02	37	142	0.264
2 air	1.00E-04	6.67E-06	1.72E-05	7.66E-06	2.93E-05	6.70E-02	45	142	0.319
3 air	5.19E-05	3.46E-06	8.92E-06	3.89E-06	1.55E-05	3.55E-02	24	138	0.171
Average	7.82E-05	5.21E-06	1.34E-05	5.96E-06	2.36E-05	5.40E-02	35	141	0.251
Ambient	N/A	N/A	N/A	N/A	3.33E-07	7.62E-04	N/A	N/A	N/A
1 no air	2.29E-06	1.53E-07	3.93E-07	6.30E-04	6.85E-07	1.57E-03	1	138	0.008
2 no air	4.25E-05	2.83E-06	7.30E-06	1.20E-02	1.30E-05	2.97E-02	19	135	0.143
3 no air	3.56E-05	2.37E-06	6.12E-06	9.10E-03	1.07E-05	2.45E-02	16	134	0.121
Average	2.68E-05	1.79E-06	4.60E-06	7.25E-03	8.13E-06	1.86E-02	12	136	0.090
Ambient	N/A	N/A	N/A	N/A	3.66E-07	8.38E-04	N/A	N/A	N/A

Where:

Surface Area of Tank Solution = 15 ft2
Surface Area of Parts = 5.82 ft2
Air Agitaion Rate Run #1 = 0.87 cfm/ft2tank
Air Agitaion Rate Run #2 = 0.87 cfm/ft2tank
Air Agitaion Rate Run #3 = 0.89 cfm/ft2tank
lb/hr is from the Flow Rate and Mass Emission Rate Spreadsheet
lb/hr-ft2 tank = lb/hr / Surface Area of Tank Solution
lb/hr-ft2 parts = lb/hr / Surface Area of Parts
lb/hr-cfmair = lb/hr-ft2tank / Air Agitation Rate per ft2tank
ppm is from the Flow Rate and Mass Emission Rate Spreadsheet
gr/dscf is from the Flow Rate and Mass Emission Rate Spreadsheet
mg/dscm = gr/dscf*2288.3
mg/hr = lb/hr x 453592
amperes is the average plating amperage from the facility's ammeter (no totalizing amp-hr meter)
mg/A-hr = mg/hr / average plating amperage during testing period

APPENDIX

Field Data, Calibration Data, and Laboratory Results

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Date: 9/3/98

Test No. 98-109

Sampling Location: Cal Tech

Sample Train #5

TRAVERSE SOURCE TEST DATA

Pre-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.006 cfm @ 15 "Hg vac
(Pitot Tube Leak Check ✓)

K = 0.587
Run #1
Air Agitation

Post-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.008 cfm @ 3 "Hg vac
(Pitot Tube Leak Check ✓)

Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Velocity Head ("H_2O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Calculated Orifice ΔP ("H_2O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vacuum "Hg
			001.258										
4:30p	+15	1	17.4	0.10	95	21.60	0.649	1.40			97	97	2
	+30	2	29.1	0.14	95	25.56	0.768	1.95			95	96	2
	+45	3	42.0	0.15	92	26.39	0.797	2.12			99	96	2
	+60	4	56.2	0.15	90	26.34	0.799	2.15			104	96	3
5:35p	+15	5	68.6	0.15	91	26.36	0.798	2.16			107	98	2
	+30	6	80.7	0.14	91	25.47	0.771	2.00			104	98	2
	+45	7	93.6	0.15	90	26.34	0.799	2.17			108	100	2
	+60	8	108.325	0.16	90	27.23	0.824	2.33			110	100	2
											100.3		
(Net Vol. Uncorr.)			101.067	Avg.	91.8	25.66		2.04					

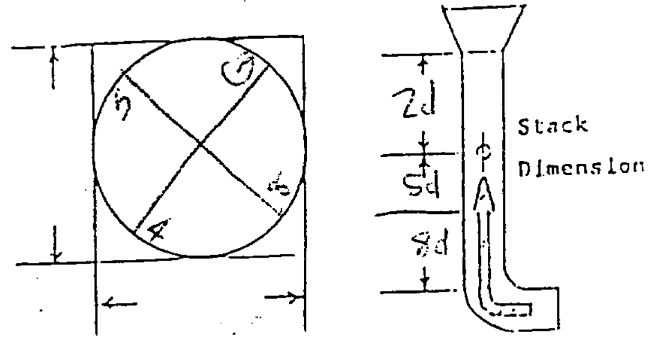
Nozzle #
Nozzle Diameter ______ mm (0.3212 ")
Barometric Pressure 28.70 "HgA
Static Pressure in Stack ______ "HgA (+/-) 0.041 "H_2O)

Recorded By C.L.
Pitot Factor 1.00

Calibration Data

Inclined Manometer	No. 715	(Cal: N/A)
Magnehelic No.	N/A	(Cal:)
Pitot Tube No.	NIST TRACEABLE	(Cal: STD.)
Potentiometer No.	20304	(Cal: 7/31/98)
Thermocouple No.	20113	(Cal: 7/31/98)
Gas Meter No.	NO715	(Cal: 7/30/98)
Meter Corr. Factor:	1.0042	

Type Sampling Probe Glass



SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-109 Date: 9/3/98

Sampling Location: Cal Tech Sample Train 14

TRAVERSE SOURCE TEST DATA

Pre-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.006 cfm @ 15 "Hg vac
(Pitot Tube Leak Check ✓)

Run#2
Air Agitation

Post-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.004 cfm @ 7 "Hg vac
(Pitot Tube Leak Check ✓)

Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Velocity Head ("H_2O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Calculated Orifice ΔP ("H_2O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vacuum "Hg
			108.535										
6:48p	+15	1	120.1	0.14	90	25.45	0.730	1.80			101	101	5
	+30	2	133.6	0.19	91	29.67	0.850	2.45			103	100	7
	+45	3	146.6	0.18	90	27.20	0.781	2.07			106	100	7
	+60	4	159.8	0.18	90	28.85	0.828	2.33			107	100	7
	+15	5	171.9	0.14	40	25.45	0.730	1.82			108	100	5
	+30	6	185.5	0.18	90	28.85	0.828	2.32			104	100	7
	+45	7	198.2	0.15	90	26.34	0.756	1.95			108	100	7
	+60	8	209.725	0.17	89	28.02	0.800	2.21			107	100	5
											107.6		
(Net Vol. Uncorr.)			101.190	Avg.	90.0	27.48		2.12					

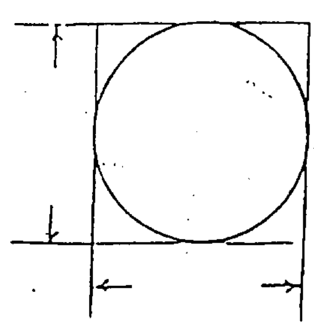
Nozzle # ✓
Nozzle Diameter ________ mm (0.3125")
Barometric Pressure ________ "HgA
Static Pressure in Stack........................ "HgA (+/⊖ 0.41 "H_2O)

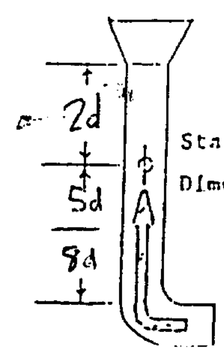
Recorded By C.W.
Pitot Factor..................... 1.00

Calibration Data

Inclined Manometer N0715 (Cal: N/A)
Magnehelic No. N/A (Cal:)
Pitot Tube No. NIST TRACEABLE (Cal: 5/98)
Potentiometer No. 20324 (Cal: 7/31/98)
Thermocouple No. 20113 (Cal: 7/3/98)
Gas Meter No. N0715 (Cal: 7/30/98)
Meter Corr. Factor: 1.0042

Type Sampling Probe Glass





Stack Dimensions

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-109 Date: 9/4/98

Sampling Location: Cal Tech Sample Train #15

TRAVERSE SOURCE TEST DATA

Pre-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.000 cfm @ 15 "Hg vac
(Pitot Tube Leak Check ✓)

K = 0.587
Run #3
Air Agitation

Post-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.000 cfm @ 2 "Hg vac
(Pitot Tube Leak Check ✓)

Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Velocity Head ("H2O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Calculated Orifice ΔP ("H2O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vacuum "Hg
6:49p			310.627								85	85	2
	+15	1	318.3	0.14	81	25.24	0.471	0.71			86	85	2
	+30	2	326.1	0.16	82	27.00	0.503	0.81			88	85	2
	+45	3	334.6	0.18	82	28.64	0.535	0.91			87	84	2
	+60	4	342.1	0.14	81	25.24	0.471	0.71					
7:53pm											90	88	2
	+15	5	349.3	0.14	80	25.21	0.471	0.72			89	87	2
	+30	6	357.3	0.17	81	27.81	0.519	0.87			92	88	2
	+45	7	365.1	0.16	81	26.98	0.504	0.82			94	88	
	+60	8	373.015	0.14	80	25.21	0.471	0.73					
											87.6		
(Net Vol. Uncorr.)			62.388	Avg.	81.0	26.42		0.79					✓

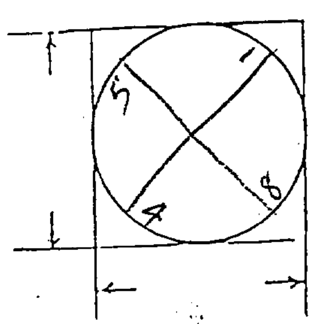
Nozzle # ✓
Nozzle Diameter __________ mm (0.250 ")
Barometric Pressure 28.95 "HgA
Static Pressure in Stack .... "HgA (+/-) 0.37 "H2O)

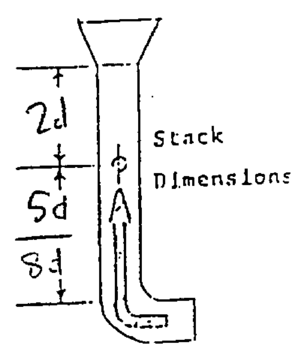
Recorded By C.W.
Pitot Factor 1.00

Calibration Data

Inclined Manometer AF0715	(Cal: N/A)
Magnehelic No. N/A	(Cal:)
Pitot Tube No. NIST TRACEABLE	(Cal: STD.)
Potentiometer No. 20304	(Cal: 7/31/98)
Thermocouple No. 20113	(Cal: 7/31/98)
Gas Meter No. N0715	(Cal: 7/30/98)
Meter Corr. Factor: ~~N0715~~ 1.0042	

Type Sampling Probe Glass





SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98

Date: 9-3-98

Sampling Location: CAL. TECH. PLATING

Sample Train CLIMB

TRAVERSE SOURCE TEST DATA

Pre-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.001 cfm @ 15 "Hg vac
(Pitot Tube Leak Check ________)

Post-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.002 cfm @ 12 "Hg vac
(Pitot Tube Leak Check ________)

Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Velocity Head ("H_2O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Calculated Orifice ΔP ("H_2O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vacuum "Hg
1630 Hrs			501.728					2.3			99	100	11
+15 min			514.0					2.3			103	99	11
+30			528.8					2.2			106	99	10
+45			539.0					2.2			107	99	[illegible]
+60			552.0					2.2			108	99	[illegible]
+75			564.5					2.2			108	99	[illegible]
+90			577.1					2.3			109	99	10.5
+105			590.0					2.3			[illegible]	99	[illegible]
+120			602.8					2.3			[illegible]	100	[illegible]
+135			615.0					2.3			110	100	10.5
+150			630.2					2.3			109	100	10.5
+165			641.4					2.3			109	100	10.5
+180			654.3					2.3			109	99	10.5
+195			667.3					2.3			109	100	10.5
+210			680.1					2.3			110	100	10.5
+225			692.1					2.3			109	100	10.5
+240			705.9					2.3			110	100	10.5
+255			719.875					2.3			109	100	10.5
								2.3			1038		

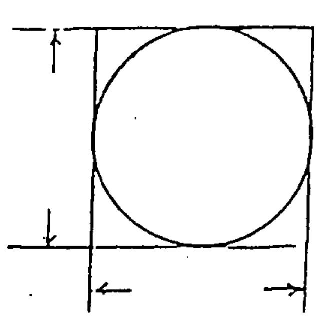
(Net Vol. Uncorr.) 217.147 Avg.

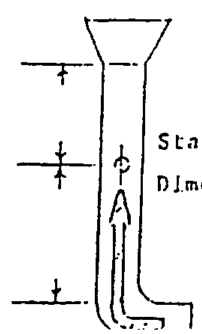
Nozzle #
Nozzle Diameter ________ mm (______ ")
Barometric Pressure ________ "HgA
Static Pressure in Stack.................... ________ "HgA (+/- ________ "H_2O)

Recorded By E. J. RAMIREZ
Pitot Factor.................... ________

Calibration Data

Inclined Manometer ________ (Cal: N/A)
Magnehelic No. ________ (Cal: ________)
Pitot Tube No. ________ (Cal: ________)
Potentiometer No. NO314 (Cal: 7-31-98)
Thermocouple No. ________ (Cal: ________)
Gas Meter No. NO714 (Cal: 7-31-98)
Meter Corr. Factor: 1.0023





Type Sampling Probe Glass

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-09 Date: 9-4-98

Sampling Location: CAL-TECH. PLATING Sample Train A.1.M.B

TRAVERSE SOURCE TEST DATA

Pre-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.004 cfm @ 15 "Hg vac
(Pitot Tube Leak Check ________)

Post-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.012 cfm @ 12 "Hg vac
(Pitot Tube Leak Check ________)

Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Velocity Head ("H2O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Orifice ΔP ("H2O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vacuum "Hg
								2.2			79	78	10.5
1000	Hrs		719.354					2.3			85	79	10.5
+15	min		731.5					2.3			92	82	10.5
+30			744.0					2.3			92	83	10.5
+45			756.4					2.3			96	86	10.5
+60			769.5					2.3			97	87	10.5
+75			781.5					2.3			96	88	11.0
+90			794.1					2.4			99	90	11.0
+105			806.5					2.4			99	90	11.0
+120			819.3					2.4			100	90	11.0
+135			831.9					2.4			100	91	11.0
+150			844.6					2.4			101	92	11.0
+165			857.2					2.4			101	92	11.0
+180			869.8					2.4			101	92	11.0
+195			882.6					2.4			101	92	11.0
+210			895.3					2.4			101	92	11.0
+225			908.0					2.4			101	92	11.0
+240			920.8					2.4			99	91	11.0
+255			933.620										
											92.5		
			214.266	Avg.				2.4	OA 2.3			98.1 OA	

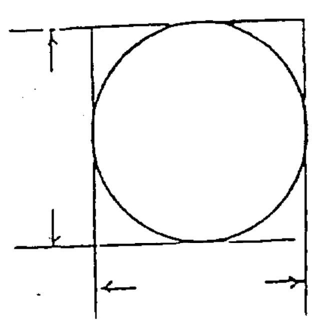
(Net Vol. Uncorr.) 431.413 OA

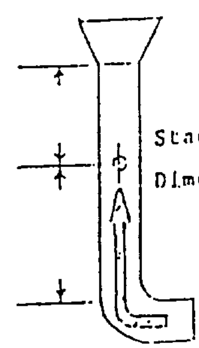
Nozzle #
Nozzle Diameter __________ mm (________ ")
Barometric Pressure __________ "HgA
Static Pressure in Stack .... __________ "HgA (+/- __________ "H2O)

Recorded By E. J. RAMIREZ
Pitot Factor .... __________

Calibration Data

Inclined Manometer ________	(Cal: N/A)
Magnehelic No. ________	(Cal: ________)
Pitot Tube No. ________	(Cal: ________)
Potentiometer No. N314	(Cal: 7-31-98)
Thermocouple No. ________	(Cal: ________)
Gas Meter No. #0714	(Cal: 7-31-98)
Meter Corr. Factor: 1.0023	




Stack Dimensions

Type Sampling Probe GLASS

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-109 Date: 9/4/98

Sampling Location: Cal tech Sample Train #4

TRAVERSE SOURCE TEST DATA

Pre-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.01 cfm @ 15 "Hg vac
(Pitot Tube Leak Check ✓)

K= 0.587
Run#1
No Agitation

Post-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.03 cfm @ 3 "Hg vac
(Pitot Tube Leak Check ✓)

Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Ø Velocity Head ("H₂O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Calculated Orifice ΔP ("H₂O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vacuum "Hg
			210.186										
4:20pm	+15	1	222.8	0.17	83	27.86	0.832	2.12			75	73	3
	+30	2	235.4	0.16	80	26.95	0.809	2.05			84	76	3
	+45	3	247.1	0.14	85	25.28	0.756	1.79			85+	77	2
	+60	4	255.8	0.12	80	23.34	0.701	1.63			90	80	2
5:02pm	+15	5	270.8	0.14	80	25.21	0.758	1.85			93	83	3
	+30	6	283.5	0.16	83	27.03	0.807	2.11			83	85	3
	+45	7	296.2	0.16	82	27.00	0.808	2.13			75	87	3
	+60	8	309.339	0.17	83	27.76	0.833	2.27			97	89	3
											85.3		
(Net Vol. Uncorr.)			99.153	Avg.	81.8	26.32		1.99					

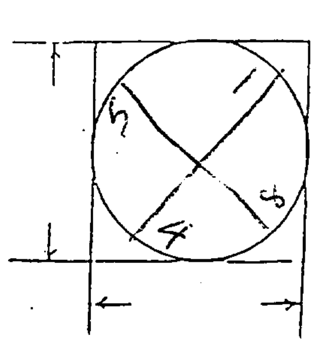
Nozzle #
Nozzle Diameter ______ mm (0.3168 ")
Barometric Pressure 28.95 "HgA
Static Pressure in Stack .... "HgA (+/-) 0.40 "H₂O)

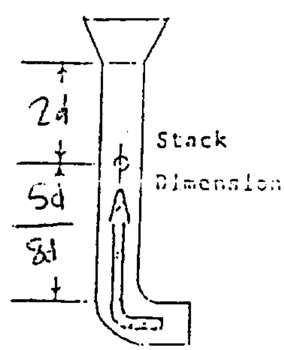
Recorded By C.U.
Pitot Factor 1.00

Calibration Data

Inclined Manometer N0715 (Cal: N/A)
Magnehelic No. N/A (Cal:)
Pitot Tube No. NIST TRACEABLE (Cal: STD.)
Potentiometer No. 20324 (Cal: 7/31/98)
Thermocouple No. 20113 (Cal: 7/31/98)
Gas Meter No. N0715 (Cal: 7/30/98)
Meter Corr. Factor: 1.0042

Type Sampling Probe Glass





SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-111
Sampling Location: Cal Tech Plating

Date: 9/11/98
Sample Train #12

TRAVERSE SOURCE TEST DATA

Pre-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.000 cfm @ 15 "Hg vac
(Pitot Tube Leak Check ✓)

K=0.552

Post-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.000 cfm @ 14 "Hg vac
(Pitot Tube Leak Check ✓)

Run #2

Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Velocity Head ("H₂O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Calculated Orifice ΔP ("H₂O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vacuum "Hg
2:30p			944.058								90	90	7
	+15	1	954.4	0.12	90	23.56	0.670	1.67			89	89	10
	+30	2	966.0	0.14	91	25.47	0.729	1.94			94	90	14
	+45	3	979.5	0.18	90	28.85	0.828	2.54			98	90	11
	+60	4	991.9	0.16	90	27.20	0.781	2.27					
3:32p											100	92	9
	+15	5	1003.4	0.13	89	24.50	0.705	1.86			99	94	10
	+30	6	1015.6	0.15	90	26.34	0.756	2.14			103	95	10
	+45	7	1027.8	0.15	90	26.34	0.756	2.17			104	96	10
	+60	8	1039.590	0.14	91	25.47	0.729	2.03					
											94.6		
	(Net Vol. Uncorr.)		95.532	Avg.	90.1	25.97		2.08					

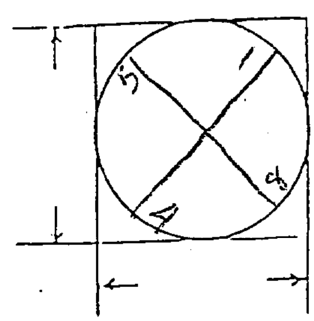
Nozzle #
Nozzle Diameter ______ mm (0.3125 ")
Barometric Pressure 28.85 "HgA
Static Pressure in Stack .... ______ "HgA (+/−) 0.40 "H₂O)

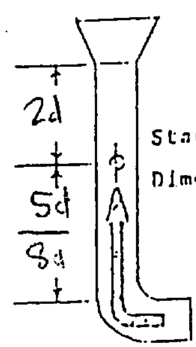
Recorded By C.G.
Pitot Factor 1.00

Calibration Data

Inclined Manometer N3714 (Cal: N/A)
Magnehelic No. N/A (Cal:)
Pitot Tube No. NIST TRACEABLE (Cal: STD.)
Potentiometer No. 20304 (Cal: 7/31/98)
Thermocouple No. 20113 (Cal: 7/31/98)
Gas Meter No. 50714 (Cal: 7/31/98)
Meter Corr. Factor: 1.0023

Type Sampling Probe Glass





Stack Dimensions

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-111
Sampling Location: Cal Tech Plating

Date: 9/1/98
Sample Train #10

TRAVERSE SOURCE TEST DATA

Pre-Test Leak Check:
Filter ____ cfm @ ____ "Hg vac
Probe 0.006 cfm @ 15 "Hg vac
(Pitot Tube Leak Check ✓)

K = 0.552

Post-Test Leak Check:
Filter ____ cfm @ ____ "Hg vac
Probe 0.004 cfm @ 20 "Hg vac
(Pitot Tube Leak Check ✓)

Run #2

Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Velocity Head ("H2O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Calculated Orifice ΔP ("H2O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vacuum "Hg
4:44p			039.865										
	+15	1	050.6	0.11	90	22.56	0.665	1.66			98	96	10
	+30	2	062.3	0.14	90	25.45	0.751	2.13			100	96	10
	+45	3	075.3	0.16	90	27.20	0.803	2.45			102	97	15
	+60	4	090.0	0.21	89	31.14	0.920	3.22			103	97	20
5:45p													
	+15	5	101.9	0.11	89	22.54	0.666	1.68			102	96	10
	+30	6	114.2	0.16	89	27.18	0.803	2.44			100	96	15
	+45	7	127.4	0.16	87	27.13	0.805	2.46			102	96	14
	+60	8	140.502	0.16	85	27.08	0.806	2.46			102	96	14
											98.7		

(Net Vol. Uncorr.) 100.637 Avg. 88.6 | 26.28 | 2.31 ✓

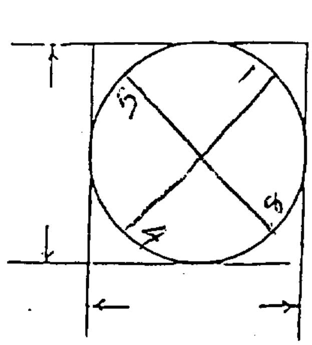
Nozzle #
Nozzle Diameter ____ mm (0.3168")
Barometric Pressure 28.85 "HgA
Static Pressure in Stack .... "HgA (+/-) 0.37 "H2O)

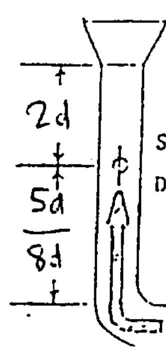
Recorded By C.U.
Pitot Factor 1.00

Calibration Data

Inclined Manometer N0714 (Cal: N/A)
Magnehelic No. JLk (Cal:)
Pitot Tube No. NIST TRACEABLE (Cal: STD)
Potentiometer No. 20504 (Cal: 7/31/98)
Thermocouple No. 20113 (Cal: 7/31/98)
Gas Meter No. N0714 (Cal: 7/31/98)
Meter Corr. Factor: 1.0023

Type Sampling Probe Glass





SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-109　　　　Date: 9-11-98

Sampling Location: CALIF. TECH. PLATING　　　　Sample Train AMR

TRAVERSE SOURCE TEST DATA

TRAIN 18

Pre-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.000 cfm @ 15 "Hg vac
(Pitot Tube Leak Check ______)

Post-Test Leak Check:
Filter ______ cfm @ ______ "Hg vac
Probe 0.00 cfm @ 7 "Hg vac
(Pitot Tube Leak Check ______)

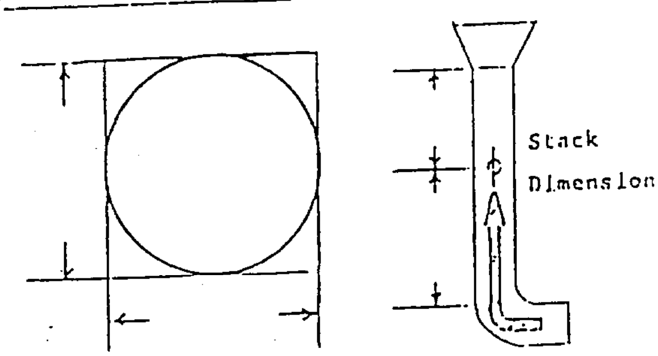
Time On	Time Off	Sample Point #	Gas Meter Reading (dcf)	Stack Velocity Head ("H_2O)	Stack Temp. °F	Calculated Velocity (fps)	Calculated Sampling Rate (cfm)	Calculated Orifice ΔP ("H_2O)	Probe Temp. °F	Filter Temp. °F	Meter Temp °F In	Meter Temp °F Out	Vacuum "Hg
								2.4			91	91	5
1439	303 min		374.091					2.4			92	90	5
+15			391.8					2.5			95	85	5.5
+30			404.7					2.5			98	87	5.5
+45			418.1					2.5			100	89	5.5
+60			431.4					2.5			101	90	5.5
+75			444.8					2.5			102	91	5.5
+90			458.3					2.5			103	93	5.5
+105			472.0					2.6			104	93	5.5
+120			485.7					2.6			104	94	5.5
+135			499.4					2.6			104	94	5.5
+150			513.4					2.6			104	94	5.5
+165			527.3					2.6			104	94	5.5
+180			541.1					2.6			104	94	5.5
+195			555.0					2.6			104	95	5.5
+210			568.8					2.6			104	95	5.5
+225			582.6					2.6			104	94	5.5
+240			596.4					2.6			104	94	5.5
+255			610.541					2.6					
											96.5		
(Net Vol. Uncorr.)			231.455	Avg.				2.5					

Nozzle #
Nozzle Diameter ______ mm (______ ")
Barometric Pressure ______ "HgA
Static Pressure in Stack .... ______ "HgA (+/- ______ "H_2O)

Recorded By E. S. RAMIREZ
Pitot Factor .... ______

Calibration Data

Inclined Manometer ______ (Cal: N/A)
Magnehelic No. ______ (Cal: ______)
Pitot Tube No. ______ (Cal: ______)
Potentiometer No. NC315 (Cal: 7-30-98)
Thermocouple No. ______ (Cal: ______)
Gas Meter No. NC715 (Cal: 7-30-98)
Meter Corr. Factor: 1.0041



Type Sampling Probe Glass

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No. 98-109

Date 8/14/98

Sampling Location DUCT OUTLET- CAPTURE HOOD

DATA SHEET FOR VERIFICATION OF CYCLONIC FLOW

Pretest Velocity Leak Check ✓
Post Test Velocity Leak Check ✓

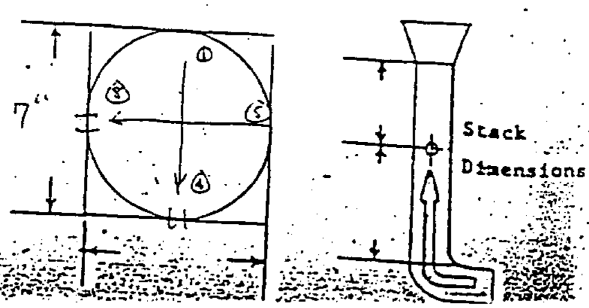
Time	Traverse Point	ΔP (in. H_2O) at 0^o Reference	Null Point Rotation Angle ($\pm \alpha$)	Comments
	1	0.14	+5	
	2	~~0.14~~ 0.14	+8	Upper Ports
	3	0.21	0	
	4	0.16	0	
	5	0.14	+10	
	6	0.15	+7	
	7	0.20	+10	
	8	0.17	+5	
	1	0.17	0	
	2	0.17	+7	
	3	0.19	+10	
	4	0.13	+5	Lower Ports
	5	0.13	+5	
	6	0.15	+5	
	7	0.18	0	
	8	0.15	0	

Recorded By [signature] /CW

Average Absolute Values of α ________

Calibration Data

Inclined Manometer ______ (Cal: N/A)
Magnehelic No. 40633 (Cal: 5/15/98)
Pitot Tube No. 40412 (Cal: 7/31/98)



SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR THERMOCOUPLE - POTENTIOMETER CALIBRATION

Field Meter : 20304
STQC # : S/N # :
Reference : ASTM 08340
STQC # : S/N # :
Temperature Source : Jofra

Date 7-31-98
Calibration by TN
Calibration for :
Semi annual X
Bi Monthly
Other

Lead Wire STQC # : 50201

Temp. Sensor STQC #	A Ref. Temp.	B Ch#1	B Ch#2	Δ°F = (B-A) Ch#1	Δ°F = (B-A) Ch#2	COMMENTS
20113	210	210	211	0	1	
40113	↓	211	211	1	1	
40114	↓	211	210	1	0	
30110	↓	210	211	0	1	
20113	410	411	411	1	1	
40113	↓	412	411	2	1	
40114	↓	411	411	1	1	
30110	↓	411	410	1	0	
20113	710	711	711	1	1	
40113	↓	711	710	1	0	
40114	↓	712	711	2	1	
30110	↓	711	711	1	1	

Lead Wire STQC # : 50202

Temp. Sensor STQC #	A Ref. Temp.	B Ch#1	B Ch#2	Δ°F = (B-A) Ch#1	Δ°F = (B-A) Ch#2	COMMENTS
20113	210	210	210	0	0	
40113	↓	211	211	1	1	
40114	↓	211	210	1	0	
30110	↓	211	211	1	1	
20113	410	411	411	1	1	
40113	↓	412	411	2	1	
40114	↓	411	411	1	1	
30110	↓	411	411	1	1	
20113	710	711	711	1	1	
40113	↓	711	710	1	0	
40114	↓	712	712	2	2	
30110	↓	711	712	1	2	

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR THERMOCOUPLE - POTENTIOMETER CALIBRATION

Field Meter : N0314 & N0315
STQC # : ______ S/N # : ______
Reference : NSTN08304
STQC # : ______ S/N # : ______
Temperature Source : Jofra

Date 7-31-98
Calibration by TN
Calibration for :
Semi annual α
Bi Monthly ______
Other ______

N0314
Lead Wire STQC # : 50201

Temp. Sensor STQC #	A	B		Δ° F = (B-A)		COMMENTS
	Ref. Temp.	Ch#1	Ch#2 N/A	Ch#1	Ch#2	
20113	212	213		+1		
	212	214		+2		
	212	214		+2		
	410	411		+1		
	410	412		+2		
	410	411		+1		
	712	712		0		
	712	713		+1		
	712	712		0		

N0315
Lead Wire STQC # : 50202

Temp. Sensor STQC #	A	B		Δ° F = (B-A)		COMMENTS
	Ref. Temp.	Ch#1	Ch#2 N/A	Ch#1	Ch#2	
20113	212	213		+1		
	212	213		+1		
	212	214		+2		
	410	411		+1		
	410	411		+1		
	410	411		+1		
	712	712		0		
	712	712		0		
	712	712		0		

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DRY GAS METER COEFFICIENT CALCULATIONS

CALIBRATION PERIOD:

BIMONTHLY ____
SEMIANNUAL X
OTHER ____

BAROMETRIC PRESSURE (P_{bar}) 29.16 in Hg

AMBIENT TEMPERATURE 70 °F

DATE: 7-31-98

PERFORMED BY: TN

Approximate Flow Rate Q (cfm)	Standard Dry Gas Meter ID# 7812470			
	Flow Rate Q_{std} (cfm)	Average Meter Temperature $\overline{T}$ (°F)	Average Meter Pressure $\overline{p}$ (in H_2O)	Corrected Flow Rate Q'_{std} (scfm)
1/4				
1/2				
3/4				
1				

1.) For non temperature compensated dry gas meters:

$$Q'_{std} = Q_{std}\left(\frac{520}{460+\overline{T}}\right)\left(\frac{P_{bar} + \frac{\overline{p}}{13.6}}{29.92}\right)$$

or Q'_{ds} ← Q_{ds}

2.) For temperature compensated dry gas meters:

$$Q'_{ds} = Q_{ds}\left(\frac{P_{bar} + \frac{\overline{p}}{13.6}}{29.92}\right)$$

3.) $Y_{ds} = \frac{Q'_{std}}{Q'_{ds}}$

* & ** The computed values in these columns must fall within the ranges indicated in their respective column headings.

*** The computed values in this column must be greater than 0.98 and less than 1.02, i.e., $0.98 < \left(\overline{Y}_{ds} \div \overline{\overline{Y}}_{ds}\right) < 1.02$.

Overall Avg., $\overline{\overline{Y}}_{ds}$ = 1.0023

Approximate Flow Rate Q (cfm)	Field Dry Gas Meter ID# NO714							
	Flow Rate Q_{ds} (cfm)	Average Meter Temperature $\overline{T}$ (°F)	Average Meter Pressure $\overline{p}$ (in H_2O)	Corrected Flow Rate Q'_{ds} (scfm)	* Coefficient Y_{ds} < (1+/− 0.05)	** (Y_{ds} max − Y_{ds} min) <=0.010	Average Coefficient $\overline{Y}_{ds}$	*** $\overline{Y}_{ds} / \overline{\overline{Y}}_{ds}$
1/4					.9844			
					1.0011			
					1.0588			
1/2					.9913			
					1.0032			
					1.0032			
3/4					.9991			
					.9975			
					1.0032			
1					.9942			
					.9944			
					.9970			

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR DRY GAS METER CALIBRATION

STANDARD IDENTIFICATION (S/N) 714 782470

DRY GAS METER IDENTIFICATION (S/N)

DRY GAS METER IDENTIFICATION (STQC) N0714

BAROMETRIC PRESSURE (P_{bar}) 29.16

AMBIENT TEMPERATURE 70

DATE: 7-31-98

CALIB. BY: TN

CALIBRATION FOR:

SEMI ANNUAL X

MONTHLY

OTHER

Approx. CFM Project	Total CF		Crit. Orif. ΔP in H_2O	Secondary Standard Dry Gas Meter						(Dry Gas Meter)					
				Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM	Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM
1/4		Start				439.3	0			.95 .25	0	503.6	0		
		End				445.2				.95 .25		509.6			
		Avg. or Total		70	1.05		21.23.62				70		21.47.22		
		Start				445.3	0					509.8	0		
		End				450.3						514.8	18.30.01		
		Avg. or Total		70	1.05		18.08.13				70				
		Start				450.4	0					515.0	0		
		End				455.9						520.2			
		Avg. or Total		70	1.05		19.57.13				70		18.54.00		
3/2		Start				475.8	0				3.2 1.0	540.2	0		
		End				484.1					3.2 1.0	548.6			
		Avg. or Total		70	3.4		14.53.60				70		15.02.05		
		Start				484.2	0					548.7	0		
		End				490.7						555.2			
		Avg. or Total		70	3.4		11.40.28				70		11.38.14		
		Start				490.8	0					555.3	0		
		End				497.6						[illegible]			

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR DRY GAS METER CALIBRATION

DATE: 7-31-98
CALIB. BY: TN
CALIBRATION FOR:
SEMI ANNUAL X
MONTHLY
OTHER

STANDARD IDENTIFICATION (S/N) 7812470
DRY GAS METER IDENTIFICATION (S/N)
DRY GAS METER IDENTIFICATION (STQC) N0714
BAROMETRIC PRESSURE (P_{bar}) 29.16
AMBIENT TEMPERATURE 70

Approx. CFM Project	Total CF		Crit. Orif. ΔP in H_2O	Secondary Standard Dry Gas Meter: Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM	(Dry Gas Meter): Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM
3/4		Start				538.4	0				6.1 / 2.2	572.9	0		
		End				518.4					6.1 / 2.2	583.1			
		Avg. or Total		70	6.2		12:36.59			70			12.47.14		
		Start				578.6	0					583.3	0		
		End				527.2						591.9			
		Avg. or Total		70	6.2		10.50.85			70			10.45.96		
		Start				527.3	0					592.0	0		
		End				540.6	16.40.57					602.0			
		Avg. or Total		70	6.2		~~12.01.30~~			70			12.30.94		
1		Start				540.8	0				10.3 / 10.0	605.6	0		
		End				549.7					10.3 / 9.8	614.8			
		Avg. or Total		70	10.5		8.39.80			70			8.49.68		
		Start				549.9	0					615.0	0		
		End				555.1						620.3			
		Avg. or Total		70	10.5		5.04.17			70			5.05.68		
		Start				555.3	0					620.5	0		
		End				562.0						627.1			

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DRY GAS METER COEFFICIENT CALCULATIONS

BAROMETRIC PRESSURE (P_{bar}) 29.12 in Hg
AMBIENT TEMPERATURE 70 °F

DATE: 7/30/98
PERFORMED BY: JN

CALIBRATION PERIOD:
BIMONTHLY ___
SEMIANNUAL X
OTHER ___

Approximate Flow Rate Q (cfm)	Standard Dry Gas Meter ID# ___ Flow Rate Q_{std} (cfm)	Average Meter Temperature $\bar{T}$ (°F)	Average Meter Pressure $\bar{p}$ (in H_2O)	Corrected Flow Rate Q'_{std} (scfm)
1/4				
1/2				
3/4				
1				

1.) For non temperature compensated dry gas meters:

$$Q'_{std} = Q_{std}\left(\frac{520}{460+\bar{T}}\right)\left(\frac{P_{bar} + \frac{\bar{p}}{13.6}}{29.92}\right)$$

or Q'_{ds} ↑ Q_{ds} ↑

2.) For temperature compensated dry gas meters:

$$Q'_{ds} = Q_{ds}\left(\frac{P_{bar} + \frac{\bar{p}}{13.6}}{29.92}\right)$$

3.) $Y_{ds} = \frac{Q'_{std}}{Q'_{ds}}$

* & ** The computed values in these columns must fall within the ranges indicated in their respective column headings.

*** The computed values in this column must be greater than 0.98 and less than 1.02, i.e., $0.98 < \left(\bar{Y}_{ds} \div \bar{\bar{Y}}_{ds}\right) < 1.02$.

Field Dry Gas Meter ID# N0715

Overall Avg., $\bar{\bar{Y}}_{ds}$ = 1.0042

Approximate Flow Rate Q (cfm)	Flow Rate Q_{ds} (cfm)	Average Meter Temperature $\bar{T}$ (°F)	Average Meter Pressure $\bar{p}$ (in H_2O)	Corrected Flow Rate Q'_{ds} (scfm)	* Coefficient Y_{ds} < (1+/− 0.05)	** (Y_{ds} max − Y_{ds} min) <=0.010	Average Coefficient $\bar{Y}_{ds}$	*** $\bar{Y}_{ds}$ / $\bar{\bar{Y}}_{ds}$
					1.0077			
1/4					1.0039			
					1.0083			
					1.0097			
1/2					1.0076			
					1.0068			
					1.0043			
3/4					1.0025			
					1.0030			
					0.9992			
1					0.9994			
					0.9969			

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR DRY GAS METER CALIBRATION

STANDARD IDENTIFICATION (S/N) 7812470

DRY GAS METER IDENTIFICATION (S/N) ____

DRY GAS METER IDENTIFICATION (STQC) NO715

BAROMETRIC PRESSURE (P_{bar}) 29.12

AMBIENT TEMPERATURE 70

DATE: 7-30-98

CALIB. BY: TN

CALIBRATION FOR:

SEMI ANNUAL X

MONTHLY ____

OTHER ____

Approx. CFM Project	Total CF		Crit. Orif. ΔP in H_2O	Secondary Standard Dry Gas Meter: Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM	(Dry Gas Meter): Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM
3/4		Start				361.6	0				6.0 2.6	871.3	0		
		End				374.5					6.0 2.0	884.3			
		Avg. or Total		70	6.2		16.38.68			70			16.45.23		
		Start				374.6	0					884.4	0		
		End				391.8						901.6			
		Avg. or Total		70	6.2		22.13.43			70			22.09.49		
		Start				391.9	0					901.7	0		
		End				402.1						911.9			
		Avg. or Total		70	6.2		13.11.12			70			13.09.2[illegible]		
1		Start				410.7	0				9.8 3.5	920.6	0		
		End				422.8					9.8 3.5	932.9			
		Avg. or Total		70	10		11.57.09			70			12.02.40		
		Start				423.0	0					933.1	0		
		End				428.0						938.2			
		Avg. or Total		70	10		4.56.28			70			4.59.54		
		Start				428.2	0					938.4	0		
		End				433.4						943.5			

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATA SHEET FOR DRY GAS METER CALIBRATION

STANDARD IDENTIFICATION (S/N) 7812470

DRY GAS METER IDENTIFICATION (S/N) _____

DRY GAS METER IDENTIFICATION (STQC) N07.5

BAROMETRIC PRESSURE (P_{bar}) 29.12

AMBIENT TEMPERATURE 70

DATE: 7/30/98

CALIB. BY: _____

CALIBRATION FOR:

SEMI ANNUAL X

MONTHLY _____

OTHER _____

Approx. CFM Project	Total CF		Crit. Orif. ΔP in H_2O	Secondary Standard Dry Gas Meter						(Dry Gas Meter)					
				Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM	Temp. (°F) In/Out	Press. (in H_2O) In/Out	Meter Read. CF	Time Min: Sec.	Elapse Time: Min.	Flow Rate CFM
1/4		Start				289.6	0				1.0 / .3	799.4	0		
		End				294.9					1.0 / .3	804.8			
		Avg. or Total		70	1.2		17.36.24			70			18.02.96		
		Start				295.0	0					804.9	0		
		End				300.7						810.6			
		Avg. or Total		70	1.2		18.59.20			70			19.02.17		
		Start				300.8	0					810.7	0		
		End				307.9						817.6			
		Avg. or Total		70	1.2		23.34.57			70			23.04.24		
1/2		Start				318.3	0				3.1 / .9	828.0	0		
		End				325.1					3.1 / .9	834.9			
		Avg. or Total		70	3.3		12.41.70			70			12.57.86		
		Start				325.2	0					835.0	0		
		End				331.8						841.5			
		Avg. or Total		70	3.3		12.19.63			70			12.11.59		
		Start				331.9	0					841.6	0		
		End				342.9						[illegible]			

U.S. DEPARTMENT OF COMMERCE

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY,
Gaithersburg, MD 20899

REPORT OF SPECIAL TEST

OF

AIR SPEED INSTRUMENTATION

March 11, 1998

Two Pitot-Static Tubes

submitted by

South Coast Air Quality Management District
Applied Science & Technology
21865 E. Copley Drive
Diamond Bar, CA 91765 4182

The calibration of the Pitot static tubes were performed in the 1 m (three-foot) by 1 m (three-foot) NIST Low Velocity Airflow Facility. The instrument under test was supported near the center of the tunnel in a manner that presented negligible interference to the flow. The air speed was measured by the NIST laboratory standard laser velocimeter on the centerline of the tunnel, upstream of the Pitot-static tubes. The air temperature, humidity, and atmospheric pressure were measured inside the tunnel.

The calibration of the Pitot-static tube consists of determining the calibration factor, K, defined as the square root of the ratio of the air speed indicated by the instrument under test to the air speed indicated by the NIST laboratory standard velocimeter. K may be a function of the Reynolds number, Re, which is expressed as

$$Re = Vd/\nu$$

where V is the air speed, d is the diameter of the Pitot-static tube, and ν is the kinematic viscosity. Two calibration cycles were done, separated by a shutdown. Each speed in each cycle is measured five times.

Tables 1 and 2 and Figure 1 show the expanded uncertainty values for the NIST air speed calibration facilities.[1] The data listed in the remaining tables are calculated from the means of the 10 measurements at each speed. Listed are the air speed measured by the NIST standard, K, Re, and the expanded uncertainty of the measurements for the instrument under test.

The expanded uncertainty of the measured values for the instrument under test, U, is given by[2]

$$U=k\sqrt{u_i^2}$$

where k is the coverage factor, taken to be 2, and the u_i are the contributions to the uncertainty from various sources. For this calibration, there are two sources of uncertainty: u_1 is the standard deviation of the ten measurements at each speed, and u_2 is one half the uncertainty at a given speed shown in Tables 1 and 2 and in Figure 1, which was obtained through the characterization of the NIST standards.

For the Director,
National Institute of Standards and Technology

Dr. George E. Mattingly
Leader, Fluid Flow Group
Process Measurements Division
Chemical Science and Technology Laboratory

[1] N. E. Mease, W. G. Cleveland, Jr., G. E. Mattingly, and J. M. Hall, "Airspeed Calibrations at the National Institute of Standards and Technology," Proceedings of the 1992 Measurement Science Conference, Anaheim, CA, 1992.

[2] B.N. Taylor and C.E. Kuyatt, "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results," NIST Technical Note 1297, National Institute of Standards and Technology, January 1993.

Expanded Uncertainties for NIST Air Speed Facilities

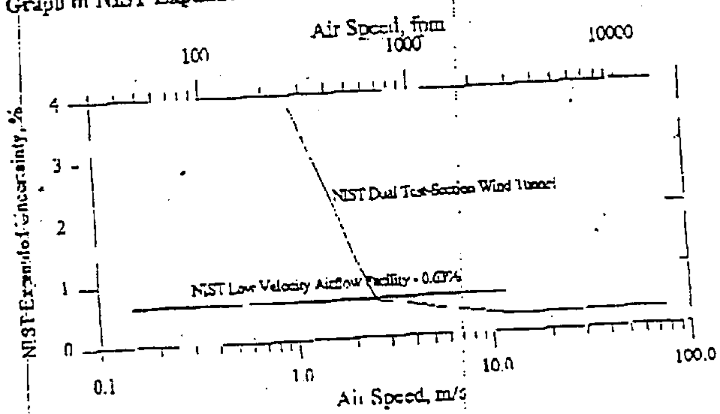
Table 1. Expanded Uncertainty of the NIST Low Velocity Airflow Facility

Air Speed, m/s	Uncertainty, (%)	Air Speed, fpm
up to 10	0.6	up to 2200

Table 2. Expanded Uncertainty of the NIST Dual Test-Section Wind Tunnels

Air Speed, m/s	Uncertainty, %	Air Speed, fpm
1	3.8	200
2	1.3	400
3	0.6	600
5	0.45	1000
10	0.31	2000
15 - 75	0.28	3000 - 15000

Figure 1. Graph of NIST Expanded Uncertainties - all facilities



SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
21865 Copley Dr., Diamond Bar, CA 91765-4182

APPLIED SCIENCE AND TECHNOLOGY
LABORATORY ANALYSIS REPORT

TO Mike Garibay, Engineer II
Source Testing & Engineering
Monitoring & Analysis

SAMPLE Four Nickel Trains
One Reagent Blank

SOURCE California Technical Plating.
Nickel Plating Tank
11533 Bradley St.
San Fernando, CA

LABORATORY NO 9253808

REFERENCE NO JSV-25-35

SOURCE TEST NO 98-109

PREPARATION NO 9239804

DATE RECEIVED 9/4/98

ANALYTICAL WORK PERFORMED, METHOD OF ANALYSIS, AND RESULTS
Nickel by CARB Method 433

Equip Number(s)	5	14	15	7
Sample point	source sample	source sample	source sample	composite ambient
Moisture gain (loss), g	56.3	50.6	33.5	120.1
Silica gel expended, percent	85	90	50	>95
Notes on train condition	(1)	(2)	(3)	(4)
Total nickel, ug	153	172	57.8	8.4

ASTD RECEIVED
OCT 05 1998
S.T. & E. BRANCH

Comments and deviations:
(1) Some graying over filter support holes.
(2) Very light graying over filter support holes.
(3) No graying on filter.
(4) Substantial graying over filter support holes.

Samples were reported with reagent blank subtracted. Reagent blank was 1.2 ug total. Samples were analyzed by West Coast Analytical Services (WCAS) by ICP/MS. (see attached report)

Date Approved: 9/29/98

Approved By: Rudy Eden
Rudy Eden, Senior Manager
Laboratory Services

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SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
21865 Copley Dr., Diamond Bar, CA 91765-4182

APPLIED SCIENCE AND TECHNOLOGY
LABORATORY ANALYSIS REPORT

TO Mike Garibay, Engineer II
Monitoring & Engineering
Monitoring & Analysis

SAMPLE Two Nickel Trains
One Reagent Blank

SOURCE California Technical Plating.
Nickel Plating Tank
11533 Bradley St.
San Fernando, CA

LABORATORY NO 9253807

REFERENCE NO JSV-25-35

SOURCE TEST NO 98-110

PREPARATION NO 9240807

DATE RECEIVED 9/6/98

ANALYTICAL WORK PERFORMED, METHOD OF ANALYSIS, AND RESULTS
Nickel by CARB Method 433

Equip Number(s)	3	4
Sample point	field blank	source sample
Moisture gain (loss), g	<0.1	45.9
Silica gel expended, percent	<10	75
Notes on train condition		(1)
Total nickel, ug	2.8	4.1

ASTD RECEIVED
OCT 06 1998
S.T. & E. BRANCH

Comments and deviations:
(1) Filter was off-center.
Samples were reported with reagent blank subtracted. Reagent blank was 2.2 ug total.
Samples were analyzed by West Coast Analytical Services (WCAS) by ICP/MS. (see attached report)

Date Approved: 9/29/98

Approved By: Rudy Eden
Rudy Eden, Senior Manager
Laboratory Services

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WCAS
WEST COAST
ANALYTICAL
SERVICE, INC.
Analytical Chemists

September 21, 1998

SCAQMD
21865 East Copley Drive
Diamond Bar, CA 91765

Attn: Joan Niertit

Job No: 39239

S

LABORATORY REPORT

Samples Received: Eight (8) Liquids
Date Received: 09/10/98
Purchase Order No: 99107

The samples were analyzed as follows:

Analysis	Page
Nickel by ICPMS	2

Charles Jacks, Ph.D.
Senior Staff Chemist

D.J. Northington, Ph.D.
Quality Assurance Officer

9840 Alburtis Avenue • Santa Fe Springs, CA 90670 • 562-948-2225 • FAX 562-948-5850 • http://www.wcaslab.com

WEST COAST ANALYTICAL SERVICE, INC.

SCAQMD
Attn: Joan Niertit

Job No: 39239
September 21, 1998

LABORATORY REPORT

Nickel
Quantitative Analysis Report
Inductively Coupled Plasma-Mass Spectrometry

Parts Per Billion (ug/l)

Sample ID	Nickel
Reagent Blank 98-109	12
Train #5	1540
Train #7	96
Train #14	1730
Train #15	590
Reagent Blank 98-110	22
Train #4	63
Train #3	50
Detection Limit:	0.1

Date Analyzed: 9-14-98 & 9-16-98

Quality Control Summary

Sample: Train #4
Matrix: Liquid

Parts Per Billion (ug/l)

	Nickel
Sample:	63
Duplicate:	64
Average:	63.5
Sample RPD:	1.6
Spike Conc:	100
MS Result:	160
% Recovery	96.5

Date Analyzed: 9-14-98

WCAS

Abbreviations Summary

General Reporting Abbreviations:

B   Blank - Indicates that the compound was found in both the sample and the blank. The sample value is reported without blank subtraction. If the sample value is less than 10X the blank value times the sample dilution factor, the compound may be present as a laboratory contaminant.

D   Indicates that the sample was diluted, and consequently the surrogates were too dilute to accurately measure.

DL   Detection Limit - Is the minimum value which we believe can be detected in the sample with a high degree of confidence, taking into account dilution factors and interferences. The reported detection limits are equal to or greater than Method Detection Limits (MDL) to allow for day to day and instrument to instrument variations in sensitivity.

J   Indicates that the value is an estimate.

ND   Not Detected - Indicates that the compound was not found in the sample at or above the detection limit.

ppm ppb   Parts per million (billion) in liquids is usually equivalent to mg/l (ug/l), or in solids to mg/kg (ug/kg). In the gas phase it is equivalent to ul/l (ul/m^3).

TR   Trace - Indicates that the compound was observed at a value less than our normal reported Detection Limit (DL), but we feel its presence may be important to you. These values are subject to large errors and low degrees of confidence.

kg kilogram	mg milligram	l liter	m meter
g gram	ug microgram	ul microliter	

QC Abbreviations:

Control & Warning Limits   QC Limits are determined from historical data. The test value must be within the Control Limits for the test to be considered valid. Based on historical data, the confidence intervals are 95% for warning limits and 99% for control limits.

% Error   Percent Error - This is a measure of accuracy based on the analysis of a Laboratory Control Standard (LCS). An LCS is a reference sample of known value such as an NIST Standard Reference Material (SRM). The % Error is expressed in percent as the difference between the known value and the experimental value, divided by the known value. The LCS may simply be a solution based standard which confirms calibration (ICV or CCV - initial or continuing calibration verification), or it may be a reference sample taken through preparation and analysis.

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
21865 Copley Dr., Diamond Bar, CA 91765-4182

MONITORING AND ANALYSIS
LABORATORY ANALYSIS REPORT

LABORATORY NO	9258806
REFERENCE NO	JSV-25-45
SOURCE TEST NO	98-111
PREPARATION NO	9240808
DATE RECEIVED	Sept. 15,1998

TO Mike Garibay, Engineer II
Source Testing & Engineering
Monitoring & Analysis

SAMPLE Four Nickel Trains
One Reagent Blank

SOURCE California Technical Plating.
Nickel Plating Tank
11533 Bradley St.
San Fernando, CA

ANALYTICAL WORK PERFORMED, METHOD OF ANALYSIS, AND RESULTS
Nickel by CARB Method 433

Equip Number(s) Sample point	6 field blank	10 source sample	12 source sample	18 composite ambient
Moisture gain (loss), g	0.2	26.2	32.3	25.4
Silica gel expended, percent	<10	50	40	85
Notes on train condition			(1)	(2)
Total nickel, ug	2.0	63.4	73.4	5.0

Comments and deviations:
(1) Very light graying over filter support holes.
(2) Light graying over filter support holes.

Samples were reported with reagent blank subtracted. Reagent blank was 1.6 ug total. Samples were analyzed by West Coast Analytical Services (WCAS) by ICP/MS. (see attached report WCAS Job No 39331)

Date Approved: 11/25/98

Approved By: Rudy Eden
Rudy Eden, Senior Manager
Laboratory Services

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WCAS
WEST COAST ANALYTICAL SERVICE, INC
Analytical Chemists

September 28, 1998

SCAQMD
21865 East Copley Drive
Diamond Bar, CA 91765

Attn: Joan Niertit

Job No: 39331

D

LABORATORY REPORT

Samples Received: Five (5) Liquids
Date Received: 09/21/98
Purchase Order No: 99107

The samples were analyzed as follows:

Analysis	Page
Nickel by ICPMS	2

Charles Jacks, Ph.D.
Senior Staff Chemist

D.J. Northington, Ph.D.
Quality Assurance Officer

This report is to be reproduced in its entirety.

9840 Alburtis Avenue • Santa Fe Springs, CA 90670 • 562-948-2225 • FAX 562-948-5850 • http://www.wcaslab.com

SCAQMD
Attn: Joan Niertit

Job No: 39331
September 28, 1998

LABORATORY REPORT

Nickel
Quantitative Analysis Report
Inductively Coupled Plasma-Mass Spectrometry

Parts Per Billion (ug/l)

Sample	Nickel
98-111 Reag Blank	16
Train #6	36
Train #10	650
Train #12	750
Train #18	66
Detection Limit:	0.1

Date Analyzed: 9-24-98

Quality Control Summary

Sample: Train #18
Matrix: Liquid

Parts Per Billion (ug/l)

	Nickel
Sample:	66
Duplicate:	64
Average:	65
Sample RPD:	3.1
Spike Conc:	100
MS Result:	163
% Recovery	98

Date Analyzed: 9-24-98

WCAS

CALifornia TECHnical PLATING, CORP.
11533 BRADLEY AVENUE
SAN FERNANDO, CALIFORNIA 91340
(818) 365-8205 FAX (818) 365-4895

Sulfamate Nickel

Tank #63

BATH CONTROL LOG

CAPACITY: 410 GALS. 110-140 F TEMP. weekly SCHEDULE:

DATE OZ/GAL OPERATING RANGE ADDITIONS

1998	Ni 10-12	Ni $(SO_3NH_2)_2$ 42-50 45-50	Addi "A" .45-3.0	Boric Acid 4.5-7.0	SNAP-AM .2-.4	PH 3.5-4.5	Filtered Dummy	Addition
5-12	10.11 9.90	42.07	1.96	4.54	.31	3.8		Add 5 GAL SNR-24
5-19	10.40 10.10	42.92	1.92	4.50	.32	3.8	Filtered	5 GAL SNR 24
5-26	10.38	43.86	1.90	4.58	.30	3.6		OK, 1 PT AID
6-2	10.26	43.60	1.86	4.68	.31	3.8	D/Filt	OK
6-9	10.21	43.39	1.84	4.62	.30	3.6		OK
6-16	10.2 9.95	42.28	1.89	4.66	.32	3.57	D/Filt	5 GAL SNR-24
6-23	10.10	42.92	1.90	4.67	.31	3.52	D/Filt.	OK
-30	10.20	43.35	1.90	4.62	.32	3.50		OK 1 PT AID.
7-7	10.18	43.26	1.91	4.60	.32	3.52	Filtered.	OK
7-14	10.20 10.11	42.96	1.92	4.90	.31	3.51	D/Filtd.	5 GAL SNR-24 1 PT AID
7-21	10.11	42.96	1.90	4.91	.32	3.50		OK
-28	10.17	43.22	1.91	129 F 4.96	.31	3.51	Filt	OK
-4	10.20	43.35	1.90	4.92	.32	3.50		OK
-11	10.15	43.30	1.89	4.90	.33	3.50		OK 5 GAL SNR-24
-18	10.26	43.61	1.88	4.91	.32	3.52		OK
8.25	10.10	42.92	1.91	4.90	.33	3.50		5 GAL SNR 24
9.2	10.31	43.94	1.90	4.96	.32	3.52		OK

WESTERN ANALYTICAL LABORATORIES, INC.

13744 MONTE VISTA AVENUE · CHINO, CALIFORNIA 91710 · (909) 627-3628 · FAX (909) 627-0491

USTOMER SOUTH COAST AQMD

WAL NO. 8110292

DATE RECEIVED 11/12/98

TTENTION JOHN MCLAUGHLIN

DATE OF REPORT 11/17/98

AMPLE IDENTIFICATION: NICKEL SULFATE PLATING SOLUTION

CALIFORNIA TECHNICAL PLATING

TANK NO. ______ GALLONS ______ SAMPLED 11/12/98

ANALYSIS	STANDARD	RESULTS
NICKEL		10.45 78.1 g/1
NICKEL SULFATE		43.8 328 g/1
NICKEL CHLORIDE		2.62 19.6 g/1
ORIC ACID		7.60 56.9 g/1
pH		2.01
URFACE TENSION		37.9 dyne/cm

M 1002 CONT